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THE ASTRONOMICAL EXPLANATION OF A GLACIAL PERIOD.

By Sir Robert Ball (*Astronomer Royal of Ireland*).

IT has been often suggested that there might be some astronomical explanation of that remarkable period in the earth's history which geologists designate as Glacial. Indeed it is doubtless known to the readers of Knowledge that the late Dr. Croll discussed the subject at much length in his ingenious work entitled "Climate and Time." I have recently undertaken the investigation of the astronomical foundation of the theory at which Croll has laboured. I found, much to my surprise, that this capable geologist was quite unacquainted with the true astronomical doctrine on the subject. He had been doubtless misled by a strange passage in Sir John Herschel's well-known book, "The Outlines of Astronomy." It seems that this eminent astronomer made a curiously erroneous statement in a matter bearing directly on the causes of glaciation. It was perhaps not unnatural for other writers to accept without question a proposition of a mathematical character, when it seemed to be authenticated by so illustrious a name as that of Herschel. Anyone, however, who possesses sufficient mathematical knowledge, will be able to convince himself that Herschel wrote down a statement which was quite wrong. There is not the least doubt that Herschel himself would have readily admitted that he had made a mistake if his attention had been sufficiently given to the matter. The worst of it is that Croll and other writers adopted Herschel's mistake as a scientific verity, and reared on this untrustworthy foundation no small superstructure of figures and arguments.

It is the object of this paper to indicate clearly the character of the error to which I have referred, and to substitute for it the correct mathematical theory. It will not be necessary for me to enter into the subject at any great length, for it is given in a little work entitled "The Cause of the Ice Age," which has just appeared, and in which the calculations herein referred to will be found fully developed. I believe, however, that the subject is of sufficient interest to justify me in giving some further account of it here.

I will say once for all that the rectification of the error to which I have referred makes the astronomical theory a far more potent factor in the explanation of ice ages than appeared to be the case so long as the erroneous view was entertained. Let me at once commence to explain the matter.

It is the radiation from the sun which prevents the surface of the earth from having a temperature nearly as low as that of space itself. We shall certainly not exaggerate if we suppose that our earth when deprived of sunbeams would have a temperature at least three hundred degrees Fahr. below that which it has at present. It is essential to bear this fact in mind, for it thus becomes evident that a small relative fluctuation in the total amount of heat received by the earth may cause a large alteration in terrestrial temperature. For the sake of illustration, we may assume the changing temperature to be proportional to the change in the amount of heat received. On this supposition an alteration of one-tenth in the heat received would cause a change in temperature to the extent of thirty degrees. I do not, however, maintain that the connection between temperature and the receipt of solar heat is at all so simple as is here supposed. My object will have been gained if the illustration suffices to show that even so great a climatic change as the advent of an ice age supposes does not necessarily require any very large proportional alteration in the daily receipt of heat from the sun.

Suppose that the total heat received from the sun on one hemisphere of the earth during the course of a twelvemonth be represented by one hundred, we proceed to consider how these parts are shared between the seasons. I mean by "summer" the interval from the vernal equinox to the autumnal, and by "winter" the interval from the autumnal equinox to the vernal. With this understanding, sixty-three parts of heat are received on each hemisphere during its summer, and the remaining thirty-seven parts during the winter. It is the announcement of this law of distribution which forms the novel feature in the present communication. Herschel's erroneous statement was to the effect that the heat was equally distributed, so that fifty parts were received in summer and fifty parts in winter. Accurate knowledge on this point is of essential importance in attempting to understand the cause of an ice age.

It will be sufficiently manifest to any student of Dr. Croll's works that he had unfortunately adopted the error that it is the object of this paper to rectify. There is not the slightest indication that he possessed a knowledge of the true law of distribution of heat between the two seasons. Had he done so he could have made his argument far stronger than it actually is.

We have now to consider the other factor in the

astronomical theory. It arises from the perturbation of the earth's orbit by the influence of the planet. At present the ellipse which forms the earth's orbit differs but little from a circle. Its form is, however, not permanent. The disturbances caused by the other planets, especially Jupiter and Venus, make the eccentricity to fluctuate when sufficiently long periods of time are contemplated. In the lapse of hundreds of thousands of years, the shape of the ellipse oscillates between the circle and the oval, so that, not once or twice, but many times in the course of geological time the orbit described by our earth has assumed a relatively extreme type. We are able to form an estimate of the eccentricity possessed by the orbit when all the circumstances conspire to make it as eccentric as possible. In the extreme case, one season of the year may amount to as much as a hundred and ninety-nine days, leaving but a hundred and sixty-six for the other. The contrast between this condition of things and the present condition will be best realized by observing that the difference between the lengths of the seasons at present is only seven days, while, in the extreme case, it may amount to so much as thirty-three days.

We have now obtained the numerical elements on which the astronomical explanation of an ice age depends. We have seen that under all circumstances sixty-three per cent. of the total heat on the hemisphere must be received in summer, and thirty-seven per cent. in winter. This statement is true whatever be the shape of the ellipse described on the earth, or whatever be the direction in which the line of equinoxes crosses it. It will remain true even when one of the seasons is a hundred and sixty-six days, and the other a hundred and ninety-nine.

There are two cases to be specially considered. First, that in which the summer is a hundred and sixty-six days, and the winter a hundred and ninety-nine. Second, that in which the summer is a hundred and ninety-nine days, and the winter a hundred and sixty-six. There will be a profound difference between the climates in the two cases supposed. Let us take the first, in which the summer is as short as it is possible for that season to become. The hemisphere must then receive sixty-three parts of heat in the comparatively brief period of a hundred and sixty-six days. The result is a summer intensely hot, so far as the direct radiation of the sun is concerned. The winter which follows has now its greatest length, and thirty-seven parts of heat have to suffice for a hundred and ninety-nine days. The temperature in that season must therefore sink extremely low. The hemisphere under consideration will therefore have very hot and short summers, and very long and cold winters. The circumstances are such as would enable the winter deposit of ice and snow to increase from year to year. Thus would be provided the ice sheet, characteristic of a Glacial Period.

As the summer in the northern hemisphere is simultaneous with the winter in the southern, and *vice versa*, it follows that on the unglaciated half of the earth there will be a long summer of a hundred and ninety-nine days, and a short winter of a hundred and sixty-six. According to the invariable rule, sixty-three per cent. of the total heat received per annum by that hemisphere will arrive during the long summer of a hundred and ninety-nine days, while thirty-seven per cent. will remain for the winter of a hundred and sixty-six days. It is evident that this hemisphere will have a far more equable supply of heat than the opposite hemisphere, for the larger portion of the early supply of heat is appropriated to the longer season, leaving the lesser portion for the shorter season. Is not this exactly the climatic condition that we should most desire? In those latitudes which we commonly call temperate, we often experience too much heat in the summer, and we generally like a little more in the winter. That is because our two seasons are of nearly equal length. We get sixty-three per cent. of our total heat supply in the six summer months, and thirty-seven per cent. in the six winter months. The climate would certainly be more uniform if we could arrange to have the sixty-three per cent. distributed over seven months, and the remaining thirty-seven per cent. over five months. So perfect an adjustment as this would seem, however, never to have been realized, for the difference between the lengths of the seasons can never be so much as two months; in fact it never can amount, as I have already stated, to more than thirty-three days. I trust, however, I have made it plain that there must be a wide difference between the climates of the two hemispheres, when the difference between the lengths of the seasons becomes considerable. In the more fortunate hemisphere the climate would be much more uniform than we have it at present; in the less fortunate hemisphere the seasons of summer and winter will be intensely contrasted. In it we find the conditions requisite for a Glacial Period, while the other hemisphere will be exceptionally genial.

It is an essential feature of the astronomical theory of the ice age that the glacial condition in one hemisphere must be necessarily accompanied by a genial condition in the other. We are thus able to explain not only those indications of glaciation which the rocks afford, but we can also account for the comparatively mild period which seemed to have occurred occasionally in the course of geological time. We can even exhibit, in some degree, the law by which glacial conditions and genial conditions succeeded each other. I desire it to be particularly understood that I do not now attempt to assign any date to the last Glacial Period. There is, however, one chronological element in the subject of which we can feel sufficiently confident, and which I now proceed to explain.

Let us suppose that the earth's orbit has reached a condition of maximum eccentricity; as the rate with which the eccentricity changes is very slow, we shall find that the earth's orbit will preserve for a protracted period sufficient eccentricity to produce a considerable difference between the lengths of the seasons when the other circumstances conspire. Let us further suppose that the northern hemisphere is the glaciated one, and that the southern is glowing in genial condition. Quite independently of any change in the eccentricity there is a well-known cause in operation to prevent the conditions we have supposed from being permanent. Owing to the phenomenon of "precision," the line of equinoxes rotates in the ecliptic with a period of twenty-one thousand years relatively to the axis of the earth's orbit. It follows that in ten thousand five hundred years, after the glaciation of the northern hemisphere is at its maximum, the glaciation will have been transferred to the southern hemisphere, and the exchange will be complete, for a genial period will now have arrived to cheer the desolated north. Nor will this be permanent, for the eccentricity declines so slowly that it will often be considerable even after the lapse of another ten thousand five hundred years, and then the original condition of things will be restored. The ice will go back to the north, and the genial phase will again gladden the south. In fact, so long as the eccentricity remains high, there will be an oscillation of ice from the north to the south and back again, with a corresponding interchange of the genial conditions. How many times this may happen at any particular epoch of maximum eccentricity I do not now attempt to say. It is, however, certain that the gradual return of the earth's orbit to a nearly circular shape will prevent its indefinite repetition. After the lapse of hundreds of thousands of

years the orbit of the earth again elongates to an oval, and a recurrence of the phenomena that I have just described takes place.

The conclusion to which the astronomical theory leads us is, that in the course of time there must have been several occasions on which the necessary conditions of glaciation were found to concur. The dates of the several ice ages must have been very irregular, there being, however, a certain tendency among them to cluster together in groups separated by the comparatively brief interval indicated by the precession of the equinoxes. It is, however, essential for me to add that the severity of the different ice ages must have shown many varieties, graduating from the most intense down to a condition hardly differing from the climates with which we are familiar.

I have endeavoured to assign its true proportions to the astronomical fact which has, I believe, been a potent influence in the climatic changes of our globe, but it must not be understood that I overlook the geological agents which have undoubtedly continued in no small degree to the modification of climate. It would be here sufficient to mention a single fact to illustrate how the results that would be brought about by the operation of purely astronomical causes are often altered by terrestrial conditions. The fact that sixty-three per cent. of the heat on our hemisphere comes in summer, and thirty-seven per cent. in winter, would seem to require a vast difference between the winter temperature and the summer temperature, even with nearly equal seasons as we have at present. But in the British Isles, the proximity of the ocean has such a moderating effect on temperature that the range between summer and winter temperature is greatly reduced. To find normal temperatures so far as the astronomical conditions are involved, we must look to some locality where the moderating elements are insignificant. We find such in Siberia, where in some places the difference between the lowest winter temperature and the highest summer temperature exceeds 100° Fahrenheit. The astronomical theory is here properly exhibited.

Finally the astronomical doctrine demonstrates the vast climatic changes which must have taken place at remote periods in the earth's history, so that even if geologists had not already discovered traces of glacial periods, the mathematicians would have known that they must have existed, and would be urging the geologists now to make haste and find them.

A GOSSIP ON GHOST-NAMES.

By CANON ISAAC TAYLOR, M.A., LL.D., LITT.D.,
Author of "Words and Places," &c.

(*Continued from page* 225, *Vol.* xiv.)

IN a preceding article we discussed the names of the Hebrides, the Grampians, and Iona, which have arisen from misreadings in the texts of ancient authors, and something was said about names in the New World due to misapprehensions on the part of geographers.

Ghost-names have occasionally been obtained from epic poems, or even from novels. A good instance is the name of Manipur, of which we have lately heard so much. About 150 years ago the Manipuris, a Naga tribe, embraced Hinduism, and proceeded to call their country Manipur, because in the "Mahabharata," the great Hindu epic, the hero Arjan is said to have travelled eastward to a mythical locality called Manipur, where he married a Manipuri princess. The Islands of the Sirens, in the Gulf of Salerno, take their name from the adventures of Ulysses in the "Odyssey," the sea-washed rocks resembling a group of white-skinned maidens bathing; and the name of Westward Ho, a rising watering-place in Devon, is taken from Kingsley's novel.

We owe the name of the Atlantic Ocean to Plato's romance of the Atlantis, and the name of the Pacific Ocean to the fact that fine weather prevailed for a few weeks after Magellan had emerged from the Straits which bear his name. But even in the time of Captain Cook the Pacific was called the South Sea, a Ghost-name arising from the fact that Bilboa, not Cortez as Keats has it, standing on a peak in Darien, saw, full south of him, a glimpse of the Gulf of Panama.

California, however, affords the most striking instance of a name derived from a work of fiction. In "Las Sergus de Explandian," a Spanish romance, published in 1510, the writer describes an imaginary island, abounding in gold and precious stones, for which he invented the name of "The Great Island of California." This name seems to have struck the fancy of some of the companions of Cortez, who applied it to the Californian peninsula, at first supposed to be an island.

Names have not unfrequently taken their places on our maps owing to the mistakes of explorers. Captain Ross, in 1818, placed a lofty range of mountains across the entrance to Lancaster Sound, and named them the Croker Mountains, in honour of John Wilson Croker, an official at the Admiralty. The next year Captain Parry sailed across the imaginary mountains, which gave rise to the epigram:—

> "Old Sinbad tells us, he a whale had seen,
> So like the land, it seemed an island green;
> But Ross has told the converse of this tale,
> The land *he* saw was—*very like a whale!*"

The name of the greatest African river, the Congo, is due to a curious blunder, Congo meaning not a "river," but a mountain. In 1480, Diego Cam, who first visited the mouth of the Congo, was told by the natives that the land belonged to a great monarch whom they called Mwani Congo, a title which we now know means "the lord of the mountains." Hence the district became known as the Kingdom of Congo, and the river by which it was traversed was called the Congo River. On most maps, however, the river is designated as the "River Congo, or Zaire." The Zaire, as well as the Congo, is a Ghost-name. A negro from the coast was brought to Lisbon by the Portuguese discoverers and presented to the King, who asked him, through an interpreter, the name of the great river in his country; he replied *Zer-oco*, or *zair-oco*, "I don't know," which was supposed to mean "It is Zer," or *Zaire*, and hence the name Zaire found its place on the maps as an alternative name of the River Congo, which, as we have seen, means "mountains." The real name of the Congo is believed to be Chambesi, which is still retained by its largest affluent, and is the same name as that of the Zambesi, a word meaning in Bantu the "great river," *zam* or *cham* signifying a "river."

In many early maps a large island, called Frisland, nearly as big as Ireland, appears in the North Atlantic about 300 miles south of Iceland. It appears to be merely the southern portion of Greenland, which had been visited from the Faroes in the fourteenth century by a Venetian named Zeno. It was not till the seventeenth century that this non-existent island disappeared from our maps. But a still more remarkable case is that of Madagascar. It may safely be said that there is no such island, and that Madagascar is a mere Ghost island, which still haunts the Indian Ocean. At the end of the thirteenth century, Marco Polo, the Venetian traveller, describes, evidently from hearsay reports, derived probably from

Malay or Arab sailors, a great island, which, in different manuscripts of his travels, is called Magaster, Madagastar, or Madeigascar. This cannot have been Madagascar, as Marco Polo affirms it abounds in elephants, and that all the people are Moslems, whereas in Madagascar there are neither elephants nor Moslems. The description would, however, apply to the great projecting peninsula of Somaliland, south of the Gulf of Aden, where we still find the name Magodoxo, or Magadoza, which appears as Makdaschau in Ibu Batuta, and as Macdazur in Fra Mauro's map of 1459. Martin Behaim, misunderstanding Marco Polo's statement, inserted on his celebrated globe of 1492, which he termed his "world apple," the large island of Madeigascar (Magaster), which is plainly the country of Magadoza (Magodoxo), a portion of the mainland made into an island, and this imaginary island appeared in many later maps. At last, in 1506, the Portuguese navigator, Gonzalves, actually reached a great island, somewhat south of the position of Martin Behaim's island. This he called Ilha de San Lourenzo, because it was discovered on February 2nd, the feast of St. Lawrence. For a long time these two names, the Isle of St. Lawrence, and the Isle of Madeigascar, contended together for geographical existence, the Ghost-name, Madagascar, ultimately being adopted, as it was supposed to be the genuine native name, which, however, is Nossi Dambo, "the island of wild swine." It is only in quite recent years that the Hovas have adopted from the missionaries the name Madgaskara as the designation of their island.

Candia, which still appears on modern maps as the name of Crete, is also a Ghost-name. Candia is merely the Neo-Hellenic word *kandia*, "a channel," used by Greek sailors to denote the narrow navigable channel through the mud-locked harbour which leads to Megalo-Castron, the capital of the island. The name of this channel was given by Italian sailors to the capital, helped by the fact that the Saracens had called the castle Kandax ("moat" or "trench"), and the name of the capital was afterwards extended to the island. Even the capital has never been locally known as Candia, the Neo-Greek designation being Castron. Thus to call Crete by the name of Candia is an error of the same kind as if foreign sailors had called London by the name of the Nore, and had then extended the name to England.

Castro-Giovanni, in Sicily, which means "John's Castle," may be taken as a specimen of a very large class of errors due to folk-etymology—that is, to the desire of making ancient names significant in the local dialect. Castro-Giovanni occupies the site of Enna. This the Romans called Castrum Ennæ, a name assimilated by the Arabs to Kasr-Janni, which, after a castle had been erected on the site by Frederick II. of Aragon, became Castro-Janni, and then, by an obvious folk-etymology, was converted into Castro-Giovanni, or "John's Castle."

Such folk-etymologies are very numerous. A familiar instance is Maidenhead, in Berkshire, where a local legend has grown up as to the martyrdom of a British virgin, whose head is duly represented on the seal of the corporation. This legend is disposed of by the Anglo-Saxon form of the name, which was probably "Mædena-hythe"—timber wharf, an oak from Windsor having been granted annually by the Crown for the repair of the bridge, the town taking its name from the hithe where these logs or trunks were landed and stored till wanted. So Setubal, a port on the coast of Portugal, has been changed into St. Ubes by English sailors, as Livorno has been changed into Leghorn, Anse de Cousins, the "bay of mosquitoes," into Nancy Cousins Bay, while Burgh Walter, the castle of Walter of Douay, has become Bridgewater.

A few Ghost-names are due, not to popular misconceptions, but to the ingenuity of scholars, whose little learning has proved a dangerous thing. To them we owe three river Ghost-names, the Penk, the Cam, and the Isis.

There is a river in Staffordshire called the Penk, a name which must have been evolved to account for the name of the town of Penkridge, on "the ridge by the Penk," the Penk flowing past the town. That the Penk is a Ghost-name is established by the fact that the name of Penkridge is a corruption of the Celto-Latin name Pennocrucium, which would be the Latinized form of the Welsh *Pen-y-crug*, "the head of the mount." Plainly the name of the river is due to an erroneous analysis of the name of the town.

The name of the River Cam has also been invented by some ingenious etymologist to account for the name of Cambridge. The real name of the river is the Granta, which appears in the name of Grantchester, a village two miles above Cambridge, which represents the Roman chester on the Granta. Now *cam* is a Celtic word meaning "crooked," and cannot have designated a stream whose course is remarkable for its straightness. Moreover, in the Saxon Chronicle Cambridge is called Grantebryg, and in early charters Cambridgeshire goes by the name of Grantebrigeshire or Grantebrigiæ Comitatatus. How the name Cambridge arose can easily be explained. From the old ford on the Roman road, called the Via Devana, was derived *Camboritum*, a Celto-Latin name meaning "the crooked or oblique ford." Taking away the Latin suffix, *Camborit* would normally become Cambret, and then, when a bridge had replaced the ford, popular etymology would change Cambret into Cambridge, which first appears in the reign of Henry II. When Cambridge had become the name of the town at the bridge over the Granta, it was supposed that the proper name of the river must be the Cam; the evolution of this new river name being aided by the analogy of the names of other East Anglian towns, Bishop Stortford being at the ford over the Stort, Thetford at the ford over the Thet, and Chelmsford at the ford over the Chelmer.

Just as Cambridge is supposed to stand on the non-existent river Cam, so the Isis, which is supposed to flow past Oxford, is a mere Ghost-name, though so firmly rooted that it would be difficult to say in how many prize poems the praises of these two imaginary streams have been sung. Oxford stands on the Thames, and some fifteen miles below Oxford it is joined by a tributary called the Thame, the names of both rivers being from a Celtic word *tam*, meaning "broad," or "spreading." But the Latin name of the Thames being *Tamesis*, some too ingenious scholar seems to have conjectured that the name *Tamesis* only applied to the river below the junction of the Thame, and was a compound name, Tham-isis denoting the united streams of the Thames and the Isis, and so the main stream of the Thames at Oxford has become the Isis, which not only has a pleasant classical sound, but has lent itself to ingenious but impossible etymologies, connecting it with the names of the Exe and the Usk, both called Isca by the Romans.

BRITISH MOSSES.

By the Rt. Hon. LORD JUSTICE FRY, F.R.S., F.S.A., F.L.S.

(*Continued from page* 223, *Vol.* xiv.)

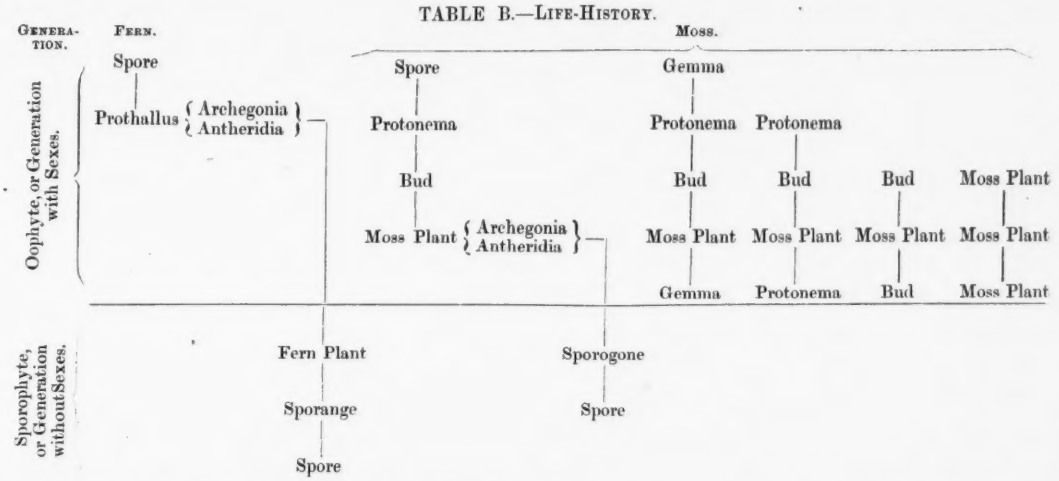
IN the account which we have given of the life-history of a Moss it will be remembered that we started with a single cell in the shape of a spore, in which was wrapped up the whole future of the life of the plant; that from that single cell all the successive developments which we have been tracing have had their origin;

and that we have then got back again to another cell, the fertilized oosphere, in which are again involved all the future life of the plant. We have travelled from cell to cell; the first part of the history of the plant, the so-called oophytic generation, is complete, and a new part of the history is to begin.

every little Moss, and we can no more account for it or understand it than we can for the creation of the starry host or of the infinite wonders of the human mind.

In the table following, the life-history, as I have already traced it, is represented by the first column under the head of Moss:—

TABLE B.—LIFE-HISTORY.



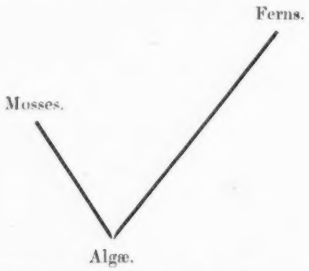
Now, what does the fertilized oosphere do? It begins a new career. It enlarges; it produces what is known as the *sporogone:* it sends up a stalk, often of considerable length and tenuity. This bursts the archegone and carries up with it the upper part of the cell, which forms the veil of the capsule; it gradually swells at the upper end till it produces the capsule. In this capsule, without any fertilization or union of cells, is produced a mass of spores of the kind with which we began our life-history. We have now completed the second part of this history, and have come round to the spore with which we started. The plant has thus began with the spore, an asexual cell, reached the point where its whole future is gathered up in a sexual cell, which has produced an organism again producing an asexual cell. We started with a spore, and have returned to a spore; we have travelled round a circle, divisible into two parts or generations, one sexual, the other asexual, and we have therefore a case of alternation of generations. To make this statement more clear, it may be observed that a generation is here spoken of as that part of the life of an organism which intervenes between the two points at which its whole future is gathered up into one cell; that such a cell is sexual when it is the result of the combination of two previously existing and independent cells; that such a cell is asexual when it is not the result of such combination; that an alternation of generations exists whenever in the complete cycle of existence or life-history there are two points at which the whole organism is reduced to a single cell, and when the forms of the organism in the two intervals of its development are different. In the Mosses, where the sporogone co-exists with and is organically connected with what I have called the Moss plant, it is evident that the two generations are not such, according to the more popular notion of that word—they are not independent nor necessarily successive.

Such in outline is the course of the life of a Moss in its fullest and most complete circuit: like every other history of the growth and change of an organism, it fills one with wonder and amazement. Think of all the promise and potentiality which is wrapped up in every little spore of

The column under the head "Fern" in like manner epitomizes the course of development of a fern, and a comparison of these two columns reveals at once the likeness and the unlikeness of the life-histories of the Moss and of the fern. In each case the spore produces a growth of a form and nature entirely unlike the mother-plant—in one case a hypha, in the other a thallus, *i.e.*, a flat leafy cellular plate. But whilst in the Moss the protonema produces the Moss plant, in the fern the prothallus itself is the home of the male and female organs, and of the sexual process, so that the fern plant belongs to the sporophytic, and the Moss plant to the oophytic generation; the fern plant is the result of the sexual union, whilst the Moss plant is produced from the asexual spore; the fern plant produces spores asexually, the Moss plant produces the sporogone as the result of the sexual union.

The observations which arise in connection with this comparison are numerous. (1) It is the belief of botanists, ever since the investigations of Hofmeister, that not Mosses and ferns only, but all the phanerogams, go through an alternation of generations consisting of the oophytic and sporophytic generations. (2) It appears that the Mosses and the Characeæ are the only groups of plants in which the conspicuous and vegetative organism—the plant, in ordinary parlance—belongs to the oophytic generation. (3) That, in consequence, the plant of the Moss is in no sense the ancestor of the plant of the fern, or of the phanerogams, but belongs to a different generation from these; and further, that the leaves, the stem, and the epidermis of the Moss have no genetic connection with the leaves, the stem, or the epidermis of our flowering plants, whilst the fibro-vascular bundles of the sporogone of the Polytrichum, and the stomata on the apophyses (or swollen bases of the capsule) of some Mosses will belong to the same generation which, in the vascular cryptogams and phanerogams, produces similar organs. (4) That the great chasm in the systematic arrangement of the vegetable kingdom between the Mosses and the ferns is thus accounted for by their belonging to different generations, so that the ferns are not in any sense

descendants of the Mosses, but only collateral relatives, as thus:—



(5) That, consequently, the Mosses not only represent the highest development known of the cellular cryptogams, but the highest point in one line of development, in which the oophytic generation took the lead in importance; whilst the vascular cryptogams and phanerogams are the results of another and more successful line of development, in which the sporophytic generation took the lead as the prominent part in the life-history.

The appearance of similar organs in two independent lines of development—*i.e.* of the leaves, stem, and epidermis—in the Mosses, and then in the ferns, without any relation of descent, is a thing well worthy of being pondered over by those who study evolution: it may suggest that the two lines of development, though independent, are governed by some common principle which brings about such like results: it may be compared with the parallelism of the stages of evolution which are reached independently by the placental and marsupial mammals.

Such are some of the reflections and conclusions which follow from the adoption of that doctrine, current amongst botanists, of the presence of two alternative generations in what appears at first sight to be the history of a single generation. It would be presumptuous in one who makes no claim to any other position than that of a learner to assail the conclusions of great authorities; but it may be allowable to observe that I have sometimes asked myself whether the theory can stand the strain of all the conclusions which arise from it; that at any rate these conclusions are such as to seem to demand that the foundations of the theory should be very firmly laid in indubitable facts; that the approach of some ferns, especially the filmy ferns, to the Mosses is, on the theory we have been adopting, merely phenomenal and delusive; that the facts we are about to consider show that Nature can suppress one whole so-called generation without imperilling the life of the organism, and that the facts known as apospony and apogony produce the same results in the case of ferns. Perhaps in future years, and with fuller knowledge, the different parts in the cycle of the life-history of the Moss may be expressed by other terms than those of alternative generations, and some larger generalization may be arrived at which will remove the difficulties which seem to stand in the way of the received doctrine.

One observation must be made to correct the generality of some of the language I have already used. I have spoken of the growth from the spore of the Mosses as a thread-like protonema: that from the spore of the ferns as a prothallus. This statement is generally but not universally true. The true Musci always, so far as is known, produce a protonema. The sphagnum produces protonema when the spore develops in water, but a prothallus when on the ground: the Hepaticæ produce sometimes a protonema, sometimes a flat plate of cells, or a mass of tissue. On the other hand, in the Ferns, whilst the ordinary first produce of the spore is a prothallus, in the filmy ferns, this is, so far as has been observed, a thread-like protonema closely resembling the like structure in Mosses. These facts show an approximation between the two great groups of cryptogams, the Ferns and the Mosses, and may hint to us the possibility of some direct genetic relation between them.

Modes of reproduction.—The remaining columns of the foregoing table B are epitomes of other modes of reproduction than the one which we have already described.

Hitherto our whole attention has been addressed to the reproduction from a spore produced in the special organ for their production—the spore capsule. But so far is this from being the only form of generation, that, in fact, one of the most striking peculiarities of the Mosses is the vast variety of their modes of reproduction.

Fig. 10 represents the upper part of the leaf of a small Moss—the *Orthotrichum phyllanthum*. It is a Moss which grows on some of our coasts. I have gathered it in abundance amongst the nests of the sea-fowl on the Farne Islands, and again on the basalt rocks under Dunstanborough Castle, also on the coast of Northumberland. It affects great elevations as well as the sea level. It grows at the highest point of vegetation on Chimborazo; it grows in great size on Cape Horn; it does not despise trees near the sea-shore as a home. This world-wide little plant rarely produces capsules, so rarely that they have only once or twice been seen, and that only quite recently; but in lieu of spores, it is reproduced by articulated cells or gemmæ, which cluster round the ends of its leaves; these drop off and produce protonema, from which the plant grows just as if the protonema had arisen from a spore.

FIG. 10.—*Orthotrichum phyllanthum*, with gemmæ, after Schimper.

Now, except in the very rare case of this plant producing a cell, the life-history of the plant differs widely from the one we have already considered—the Moss plant. The vegetable with its stalk and leaves is there, but there are no archegones, nor antherids, no fertilized oosphere, no sporogone, no capsule, and no spore; the whole sporophytic generation is excluded; the life is a short circuit which never enters upon that generation at all. This is epitomized in the second column, under the head "Moss," of table B.

The *Tetraphis pellucida* is one of our most lovely little Mosses; it grows in hollows in woods, and on damp and decaying stumps of trees, and produces capsules comparatively rarely—at least I have never found the capsules growing—but relies mainly for its reproduction on gemmæ not much different from those of the Orthotrichum, but these it carries in cups at the end of its stem, formed of large, delicate and almost translucent leaves, which with their egg-like gemmæ are a very beautiful structure. A magnified drawing of this Moss forms our Fig. 11.

FIG. 11.—*Tetraphis pellucida*, with its cup containing gemmæ, after Schimper.

The *Aulacomnium palustre* is another British Moss which is reproduced sometimes by spores, sometimes by gemmæ, but in this case the gemmæ are borne, not on the ends of the leaves or in terminal cups, but in clusters growing at the ends of special supporting stalks growing out from the plant laterally. The two forms of the plant, the spore-bearing and the gem-

bearing, are strangely unlike as regards their general appearance, and the casual observer would, I feel sure, take them for widely different plants. The question whether the plant shall adopt the one mode of reproduction or the other seems to depend, in part at least, on temperature, a high temperature tending towards the production of the gemmæ, and a lower temperature towards that of spores. The two forms are shown in Figs. 12, 13 and 14. Fig. 14 shows the plant surrounded by its stalked heads of gemmæ (*g g*). The plant, as its name

FIG. 12. *Aulacomnium palustre.* Male plant of spore-bearing form, after Dillenius.

FIG. 13.—*Aulacomnium palustre.* Female plant of spore-bearing form, after Dillenius.

FIG. 14. *Aulacomnium palustre.* Gem-bearing form, after Dillenius.

indicates, affects marshy situations, and often grows amongst sphagnum, and as this is used for orchids, and often kept in considerable heat, this form of the Aulacomnium may sometimes be seen in orchid houses in great abundance and beauty, raising its delicate heads above the level of the sphagnum.

The other form of the plant is double, *i.e.*, the male and female blossoms are produced on different plants; the former is shown in Fig. 12, and the latter in Fig. 13. This is a very handsome and strong-growing Moss.

The great diversity in the general appearance of these two forms of the same Moss is very striking; it suggests the great influence of temperature on such forms, the warmer temperature in this case producing the more delicate plant and the colder temperature the more robust. Furthermore, it is an instance of the correlation of great difference of general form with differences of modes of reproduction.

Other Mosses produce gemmæ on other parts of their structure; some on the midribs of the leaves, and some in the axils.

In the case of the Tetraphis there is reason to believe that the cup that contains the gemmæ is a modification of a male flower, and from the drawing above presented of the male flower of the Aulacomnium (Fig. 12), it would seem as if it had a tendency to produce the stalked heads of gemmæ. The drawing is a copy from one in Dillenius. I have never seen such a growth in Aulacomnium, but the drawing is probably accurate, and it suggests for investigation, as a question of interest, the relation between these stalked heads and the inflorescence of the Moss.

(*To be continued.*)

THE CAÑONS OF COLORADO.

By the Rev. H. N. HUTCHINSON, B.A., F.G.S.

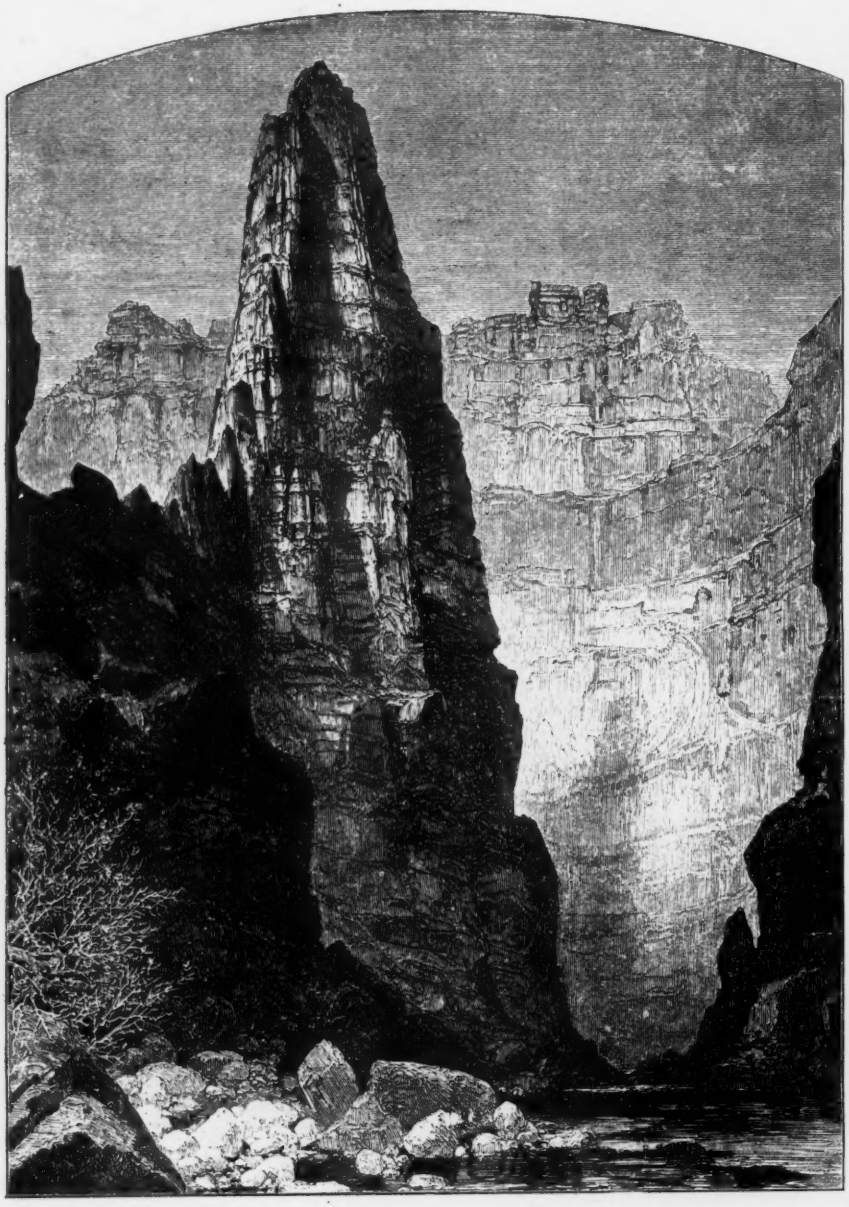
IF any readers of KNOWLEDGE wish to begin the study of Geology they cannot do better than find their way to this delightful subject through a river valley. We are all more or less familiar with brooks, streams, mountain torrents or rivers, and can, therefore, easily follow the geologist when he tells us of the useful operations performed by these agents—how they drain the surface of the earth, forming soil and bringing life and fertility with them.

It is not too much to say that a thorough knowledge of the action of rivers would go a long way in helping anyone to comprehend the nature of the changes that have in former times taken place on the earth, and to read the record of the rocks.* We need, therefore, no further apology for introducing to the reader the remarkable chasms known as the Cañons of the River Colorado of the West. They are the most stupendous monuments of the cutting power of a river which the world can show; and, moreover, they illustrate a phase of river action pure and simple, unaided by the power of rain, that can hardly be seen elsewhere.

It will be our endeavour, in this and the following paper, to give some account of the Cañons and the region in which they occur; and at the same time not only to show how they can be accounted for, but also to trace in part the geological history of the district, and to show how many interesting questions are closely bound up with the history of that one river. For this purpose we shall draw largely from the now famous monograph on "The Tertiary History of the Grand Cañon District," by Captain Dutton, published by the Government of the United States, as the second of their valuable series of geological monographs. We owe especial thanks to Captain Dutton for having given us leave to reproduce some of his beautiful illustrations.

Between the Rocky Mountains on the east, and the Cascade and Sierra Nevada Mountains on the west, occurs an elevated region known as the Western Plateau, near the middle of which lies the Great Basin, with its Salt Lake—the site of the Mormon city. Just below this, and north of the Sierra Madre range, comes the Colorado Plateau, with its river of that name. This district, in which the Cañons occur, is situated in the north-west of Arizona State, with an extension northward into Utah. Its length, north-west to south-east, is about 180 miles, and its width, north-east to south-west, about 125 miles. Its total area is between 13,000 and 16,000 square miles. The Colorado River of the West runs a very tortuous course through the middle of it. The Marble Cañon and the Grand Cañon form part of its valley. The country lying to the north of the river has been studied in detail. To the extreme north is a series of "Terraces," carved by erosion

* For a fuller account of the work of rivers see the writer's "Story of the Hills." (Seeley & Co.)



Pinnacle, in the Red Wall Limestone of the Kanab Cañon, which runs northward from the Grand Cañon towards the Terraces.

out of the Mesozoic and Lower Eocene strata, which, covering all the region of the high plateaus, suddenly terminate in a succession of high cliffs, dropping step by step to lower formations, like a great staircase. At the foot of this staircase is a comparatively smooth platform of Carboniferous rocks. These "Terraces" form one subdivision, and are a border country between the high plateaus on the north and the Grand Cañon district on the south, and belong as it were to either. It is important to bear in mind these two broad features, so different in their appearance and geological history—the "Terraces" formed of the remnants of Mesozoic and Lower Eocene strata, and the platform of Carboniferous rocks on which they rest, and through which the Cañons have been cut by the river. The main Carboniferous platform, north of the river, may be sub-divided into five distinct regions. The dividing lines between them are well marked, consisting of great "faults," or of monoclinal flexures in the strata. Abrupt lines of "faults" or displacements traverse the region, in directions north and south. These cracks and flexures, or folds, form a striking system. They are of great magnitude, and remarkable for their enormous length. Such features deserve mention, because there is evidently a close connection between the "faults" and the monoclinal folds, showing that the same force which elevated the region, and bent these strata, caused them to snap in certain definite directions. Also because they bear upon the important question of earth-movements; for Captain Dutton shows that the dislocations must have taken place quite slowly, and we may mention that similar evidence from some other regions leads to the conclusion that even a well-defined mountain range may be slowly and quietly elevated. Again, volcanic eruptions have at a recent period (geologically) taken place in some parts of this district, and he discusses the possible connection between "faults," or fissures, and volcanic phenomena. Under his scrutiny, all these processes are made to fit in harmoniously with the various stages of the excavation of the Cañons. But we must not anticipate further.

The district drained by the Grand and Marble Cañons consists of a vast platform of Carboniferous strata, which are *nearly horizontal*, as are the later rocks composing the "Terraces." This is an important fact which has had its influence in making the Cañons what they are. They are bounded on the north and east by the edges of abruptly terminated Mesozoic beds, ascending cliff above cliff, and on the west and south by their own terminal escarpments descending down to Silurian, and perhaps even Archœan rocks at the bottom of the great chasms. Had the strata of the Colorado plateau been much contorted or folded, they would have produced a different type of scenery.

The trunk of the drainage tree is the Colorado. This marvellous river, after traversing the heart of the Plateau

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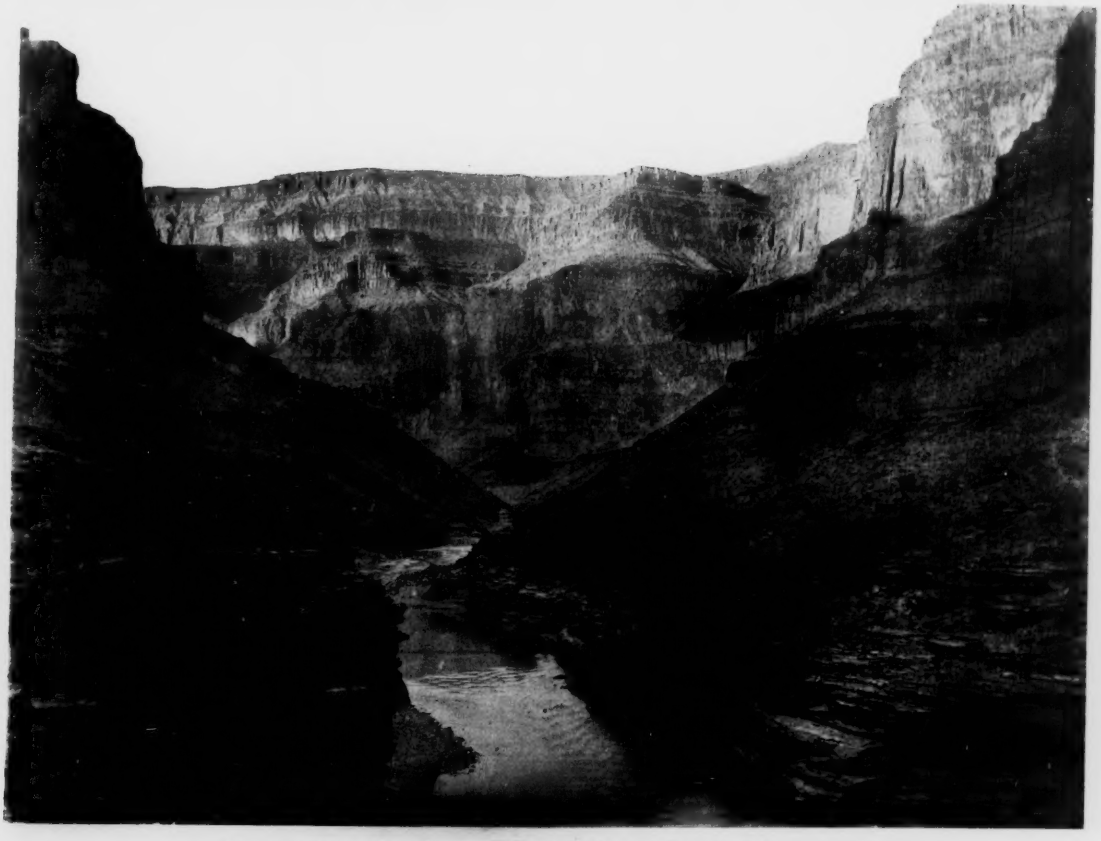


Two Photographic Views of parts of the Grand Cañon.

Taken by Mr. Robt. B. Staunton, Chief Engineer of the Denver, Colorado Cañon, and Pacific Railway.

The Automatic Engraving Company, Strode Road, Willesden Green.

XUM

Province for hundreds of miles, and nearly all the way in profound chasms, reaches the escarpment of the Echo Cliffs, where it emerges for a moment from between opposing walls of impressive magnitude into comparatively open space; but it is for a moment only. At once it begins to sink in the Carboniferous platform, another chasm called the Marble Cañon, and which further on is known as the Grand Cañon. That portion of the river which flows through these Cañons has actually cut through 10,000 to 16,000 feet of strata; but the present Cañons represent only its corrosion* through the Carboniferous and into the Archœan strata, for we must remember that the "Terraces" are quite distinct from the Cañons. The much older corrosion of the superior and newer Strata composing the "Terraces" becomes manifest only, when we restore in imagination the Mesozoic and Lower Eocene rocks which have been removed from the vicinity of the chasm. This much we may be allowed to say in anticipation of the conclusions to which we shall be led by a survey of all the evidence, that the present Grand Cañon is the work of Tertiary and even Quaternary time. So its history brings us almost to the confines of the human era.

The length of the entire chasm is about 220 miles. There are only three principal streams which drain the "Terraces," the Virgin River, Kanab Creek, and the Paria River. These enter the Colorado on the north side. Only one of them enters the Cañon, and even that is dry along a portion of its bed for the greater part of the year. This almost entire absence of tributaries is an important fact, the cause of which is obvious, viz., the dry climate which has prevailed here for a long period. Before the region was elevated to its present height, though it was surrounded by a belt of hills, these were of too moderate an elevation to intercept the clouds that passed over them, and moist winds from the west were, therefore, able to reach the interior. But when the encircling hills became lofty mountains, the wind was robbed by them of its moisture before it reached the plateau, and so this region is almost rainless. We shall dwell later on the significance of this fact. Other tributaries once existed (when there was a much greater rainfall), but ceased with the advent of the present climate. But it is time to pass on to a description of the "Terraces" and Cañons.

In the entire series of the "Terraces" the total thickness, from the top of the Carboniferous to the summit of the Eocene, is not far from 10,000 feet. "Each of the sedimentary groups of the 'Terraces,' from the Eocene to the Permian inclusive, has it own style of sculpture and architecture, and it is at first surprising and always pleasing to observe how strongly the several styles contrast with each other." These differences, he says, are as great as those between Egyptian and Greek temples, the pagodas of China, and the cathedrals of Western Europe.

We now leave the "Terraces" for the Cañons; and first, it is well to warn the reader that the Grand Cañon is so completely different from ordinary scenery and our ordinary conceptions of the grandeur and beauty of Nature that, like all innovations, it must be understood before it can be properly estimated. Those who have long and carefully studied the Grand Cañon do not hesitate for a moment to pronounce that by far the grandest of earthly scenery is contained in this steep valley, 200 miles long, 5 to 10 miles in width, and from 5000 to 6000 feet deep!

Cañons are of very various types. The common notion of a Cañon is that it is a deep, narrow gorge, with nearly vertical walls. There are plenty of these in the Plateau country; but it would be a mistake to apply this conception to the Grand Cañon.

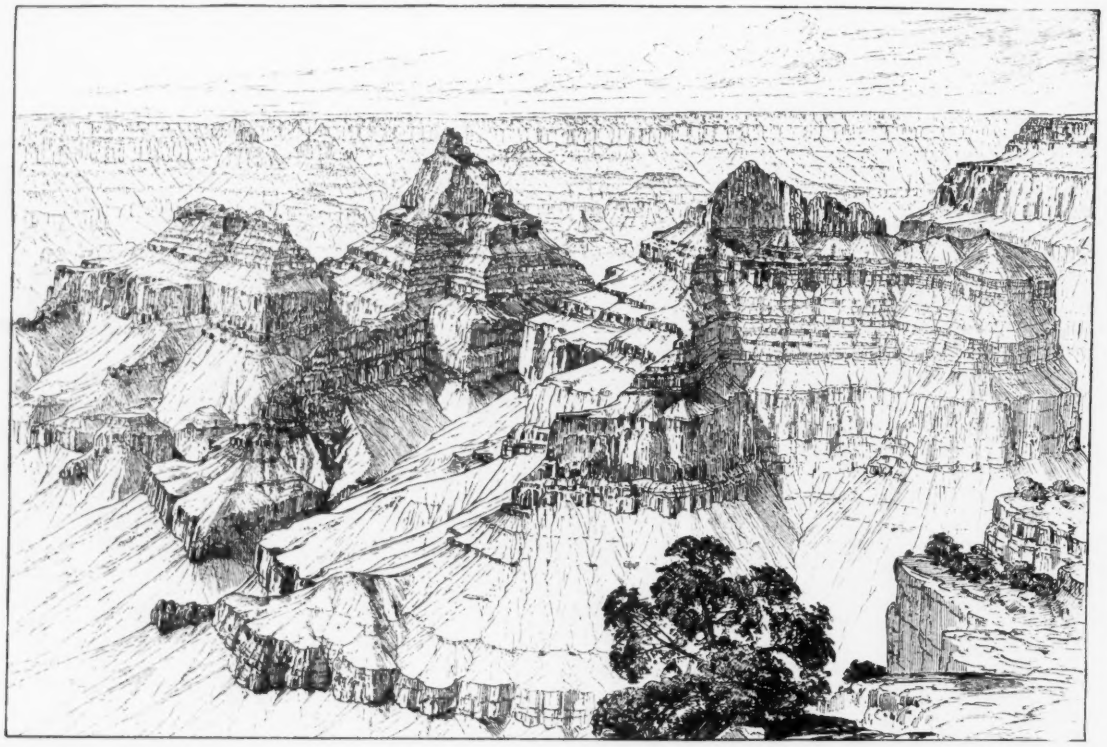
The overruling feature is the great wall—a mural front a mile or more in height, seven to ten miles distant, and receding into space in either direction. There is an inner and an outer chasm, the former of which is about 1200 feet deep. In some places the Grand Cañon is as much as twelve miles wide. In the neighbourhood of the Toroweap Valley we have a broad upper chasm five to six miles wide, with walls nearly 2000 feet high. Between these escarpments is a rough rocky plain; in this floor is cut the inner chasm 3000 feet deep. When one first comes to the brink of the chasm there comes a feeling of disappointment, for it does not seem to come up to our expectations. The river below is 300 or 400 feet wide, yet it looks only fit to turn a village mill. Its surface is a rushing torrent, yet it looks motionless as a distant lake. The ear is

Pinnacles, at the edge of the Kaibab Plateau, Grand Cañon District.

* Corrosion is a new term applied to the deepening of the channel of a stream or river. Erosion denotes the general denudation, or wear and tear of the surface of any region.

strained to catch the roar of its water, but only catches it faintly at intervals. A mottling of light and shadow is dimly perceived on its surface, yet this represents fields of white foam lashed up at the foot of some cataract, and sailing swiftly on! Another mistaken idea is that the chasm is pervaded by a deep solemn gloom, yet the truth is almost the reverse. It is only in the depths of the inner gorge that there is a suggestion of gloom. The atmospheric effects are very striking, In all the western scenery of America there is a blueness of the atmosphere. Looking through the haze at the rich strong colours of the rocks the very air becomes visible. The Grand Cañon is ever full of this haze, which fills it to its brim. The sunsets are very glorious.

that around a considerable part of the district the Eocene and Mesozoic strata terminate suddenly in great cliffs facing the Carboniferous platform, it is natural to conclude that these strata formerly extended beyond their present boundaries. The main erosion of the "Terraces" was accomplished during the Miocene period, when a moist climate prevailed. The evidence goes to show that they once spread over the entire district reaching into central Arizona, where they ended along an old shore-line. We cannot conceive of strata being formed by deposition in seas or lakes with sudden steep terminations like these cliffs; they would not end in this way against old shore-lines, and, again, they would only thin-out gradually at a long dis-



General view of Vishnu's Temple, showing horizontal stratification, Grand Cañon District. From Captain Dutton's Monograph.

It will readily be understood that the highly architectural types of scenery presented by this wonderful region are due to the following facts:—(1) The strata are nearly horizontal, so that harder layers stand out like courses of masonry, and the summits of projecting and more or less detached masses between adjacent valleys are horizontal; (2) the vertical "joints" give rise to vertical ledges and pinnacles, for atmospheric erosion takes place along these joints or natural lines of division (a structure superinduced on all rocks after their deposition, the cause of which is not thoroughly understood); (3) the great altitude of the region; (4) the dry climate, which prevents vertical walls from being washed down into sloping curves, as they would almost certainly be in a rainy country.

Returning now to the "Terraces," which necessarily were cut out before the Cañons below them, let us see what is the lesson they convey. To the geologist they bear striking testimony to an enormous amount of denudation. Seeing

tance from a shore-line by the failure of the supply of detrital material, such as mud and sand.

Erosion, or denudation, is the result of two kinds of processes, viz.:—disintegration and transportation. In the first of these are included all those agencies whereby rocks are broken up first into boulders and pebbles, sand, and finally into sand and clay. In the second are included the transporting powers of glaciers and rivers, whereby these materials are carried down to the seas, and the finer matter carried still further by ocean currents. When the *débris* produced by the disintegration of rocks is left to accumulate on a flat surface it forms a protecting mantle to the rocks beneath—and so the process is retarded. In order that disintegration may go on rapidly, the *débris* must be carried away as fast as it forms; but the efficiency of transportation depends on the declivity, or slope; the greater the slope, the greater the transporting power of streams—so that the steepest rocks suffer the most destruction. Hence, it follows that the attack of erosion

is very effective against cliffs and steep slopes, but has little effect on flat surfaces. We have three converging lines of evidence going to prove that the "Terraces" are the result of denudation, and the evidence from each is in complete harmony with this conclusion. Thus, a thorough inquiry into the evidences from (1) the stratification, (2) the displacements "or faults," and (3) the drainage-system, shows that all point in the same direction. Take the displacements, to which these strata have been subjected since their formation; judging from the thicknesses of the strata, it appears that between the close of the Carboniferous period and the local Eocene 10,000 feet of deposits were formed. It follows, therefore, that at the latter epoch the summit of the Carboniferous rocks lay at least 10,000 feet below the sea-level. There must have been a slow sinking, as all these rocks were piled up under water. It is quite clear that they have been lifted up to their present height since they were formed. This elevation is estimated at from 12,000 to 18,000 feet, and the great "faults" and displacements must be of Tertiary age, for they could not have occurred until after the Lower Eocene rocks had been deposited, These are some of the consequences of the great denudation. If by independent evidence they appear to be true, the conclusion is greatly strengthened. The present altitudes of the rocks mark the difference between the amount of displacement or uplift and the depth of erosion.

And thirdly, there is only one way of accounting for the present positions of the drainage channels. These can only be explained by assuming precisely what has already been concluded both from the stratification and the displacements, namely, by depressing the whole Grand Cañon platform many thousands of feet, and covering it with Mesozoic and Eocene beds, reducing at the same time all the "faults" and flexures until the Carboniferous strata become a smooth platform over the whole district.

The origin and history of rivers is a subject which has hitherto been somewhat neglected by geologists. It is a difficult subject, no doubt, but more use might be made of rivers in unravelling the history of a region. There are certain elementary propositions about rivers which read like truisms, but which, when followed out to their obvious consequences, become very useful. Every river must have had a beginning, and that alone implies a great deal. Water does not run uphill; yet vexed questions might have been solved by taking this fact into account. Captain Dutton has laid down the following propositions, and applied them to the solving of the drainage problem of the district in question: (1) The great rivers of a country are, as a rule, born with the country itself; (2) that their courses were determined by the conditions prevailing at the time of their origin; (3) that their positions, once established, are (with certain qualifications) immutable.

How these rules are applied to the case of the Colorado River, we will endeavour to explain in the next paper.

FACES IN THE SKY.

By A. C. RANYARD.

GIVEN two patches for eyes, with a suggestion of a nose, and a person of lively imagination will fill in the outlines of a face amongst the most unlikely surroundings, in places where the action of natural selection cannot be suspected of having formed a face by any process of protective mimicry. Thus there is a crab which bears about on its back a remarkable likeness to an old man's face; and everyone is familiar with the skull-like marking on the back of the death's-head moth. Everyone, too, recognizes the face on the moon when it is nearly full: many people see the face when it is far from full—both in waxing and waning—and some even recognize it when the moon is in the crescent form.

Dominic Cassini, the astronomer of Louis XIV., the first Director of the Paris Observatory, thought that he recognized a small but beautiful face on the moon as seen in the telescope. Fig. 1 represents a portion of a lunar

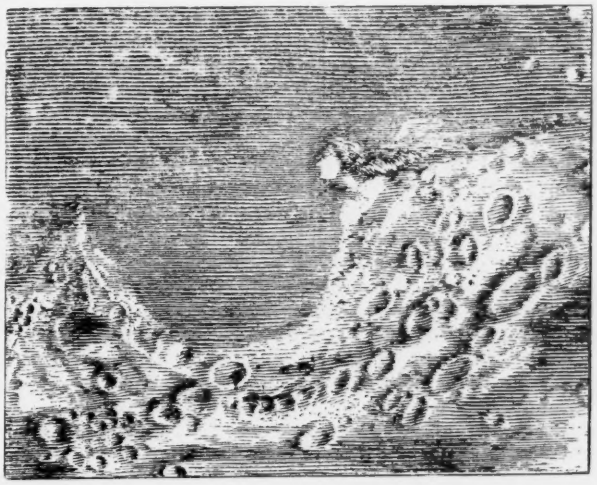


FIG. 1.—Portion of Lunar Chart of Dominic Cassin.

chart constructed by him, and published in 1680. The whole map is 20 inches in diameter, and the portion shown in Fig. 1 represents the northern edge of the Mare Imbrium. The bay between the two promontories is the Sinus Iridum, with Cape Heraclides on the right and Cape Laplace on the left. Cassini saw in Cape Heraclides the profile of a beautiful woman's face with hair streaming backwards; and curiously, Schroeter also saw a likeness to a human face in this projecting promontory, though he draws

FIG. 2.—Photographic Process Block showing the likeness of a Man's Head in the Milky Way.

it not as a beautiful woman, but as a very ugly man. I can trace no likeness to a face in the photographs of this region of the moon's surface or in the drawings of Cape Heraclides made by Löhrmann, Elger, Schmidt, Neison or Webb, several of which are reproduced by M. Flammarion in the December number of *L'Astronomie*.

Within the white circle on Fig. 2 is a face which, if seen in the sky by our wonder-loving ancestors, would have been thought miraculous and full of ominous meaning. How long it has looked down upon us I do not know.

The block has been made from Mr. Barnard's photograph of the Sagittarius region of the Milky Way, which was reproduced in the last number of KNOWLEDGE. The contour lines have been drawn upon it to indicate the position of the man's face, which will be still more clearly recognized on the collotype plate in the December number. It is well worthy of close examination. The eyes will be seen to be formed by two darkish areas, surrounded by lines of stars, and the lock of hair, or pigtail, on the right-hand side of the face, is formed by a remarkable stream of stars. The face, though in a much more ghost-like and fainter form, may be distinctly recognized on Mr. H. C. Russell's picture of the Sagittarius region, published in the March number for 1891, but it needs some patience to discover its position on Mr. Russell's photograph. A comparison between the two pictures shows how every detail of nebulous brightness corresponds in the American and Australian photographs. The mouth and nose of the face are represented by small dark areas, which are also recognizable on each of Mr. Russell's photographs, for he has sent over to England silver prints from two negatives of this region, and they correspond, as to the minutest details, with one another, as well as with Mr. Barnard's photograph. I am now inclined to think that the apparent differences of stellar magnitudes, referred to in the March number, may probably be accounted for by differences in the chromatic correction of Mr. Russell's and Mr. Barnard's instruments, in addition to differences of exposure of the photographs.

Dr. Max Wolf has taken another most successful photograph of the region of the Milky Way about ζ Cephei, with an exposure of seven hours. It shows many dark tree-like structures similar to those on the α and ξ Cygni photographs.

Part XII. of *The Old and New Astronomy* is now published. Part XIII., containing the chapter on meteors and comets, and the index, will follow shortly.

In replying to the question in the last number as to the velocity necessary to carry a gaseous molecule from the moon to the earth the answer should have been: a little over 2 miles per second, instead of $2\frac{3}{4}$ miles. If we consider the moon independently of other attracting bodies and independently of its motion about the earth, a shot fired vertically upwards from its surface, with a velocity of 1·4815 miles per second, would be carried out of the range of lunar gravity, but if a shot was fired towards the earth with the above velocity it would not lose the velocity of the moon in its orbit, and consequently would not reach the earth but would revolve about the earth in an elliptic orbit within the moon's orbit. If, however, the shot was fired from the rear side of the moon backwards in the direction of the tangent to the lunar orbit with the velocity of the moon in its orbit, in addition to a velocity sufficient to carry it against lunar gravity to a distance from the lunar surface equal to a little more than one-ninth of the moon's distance from the earth, the shot would fall to the earth.

Notices of Books.

The Story of the Hills: A popular Account of Mountains and How they were Made. By the Rev. H. N. HUTCHINSON, B.A., F.G.S. (Seeley & Co., 1892.) Mr. Hutchinson's book will be greatly welcomed by travellers in Switzerland and other mountain playgrounds. It appeals to travellers with very little specialist or technical geological knowledge, and teaches them to observe and read for themselves the wonderful story of the hills. A little knowledge with respect to natural objects greatly adds to our appreciation of them. Mr. Hutchinson's book deals with the slow moulding of mountain forms by streams and by weathering, and with the forces by which mountains have been upheaved, and will double the pleasure of a mountain trip. It is of a handy and portable size, and is illustrated with several excellent reproductions of photographs by the late Mr. W. Donkin, an expert in mountain photography, whose premature death in the Caucasus is much to be deplored.

Melanism and Melanochroism in British Lepidoptera. By J. W. Tutt. (Sonnenschien & Co.) Entomologists who are interested in the perplexing question of the causes of melanochroism will be glad to have this neatly bound reprint of an essay which has, for some time past, been appearing in sections in the pages of the *Entomologists' Record and Journal of Variation*, of which Mr. Tutt is the editor. It is to a great extent a plea for the recognition of the preponderating influence of humidity of climate in producing dark varieties of butterflies and moths; and though sometimes partaking rather too strongly of the character of special pleading, it is a useful summary of a subject which, notwithstanding that it is yet quite in its infancy, has already awakened a lively interest in the minds of many insect-hunters.

The Physical Geology and Geography of Ireland. By Edward Hull, M.A., LL.D., F.R.S. Second edition. (Stanford.) The reader who masters this book will have received a good training in the methods by which the facts of the present physical features of a country, diligently collected by careful observations in the "field," may be applied to the reconstruction of its past geological history. A multitude of details is supplied, but the matter is methodically arranged, and the whole is divided into three parts. In the first of these, which is necessarily the least attractive of the three, the author lays his foundation by giving a circumstantial account of the geological formations of which the country is composed. The most noteworthy features under this head are the enormous extent of the carboniferous limestone which constitutes the great central plain, the almost entire absence of mesozoic strata from the island, and the extensive volcanic series of Miocene age in the north-east, the wonders of which culminate in the basaltic columns of the Giant's Causeway. The second part is more imaginative; present facts are made to tell the history of past disturbances, and to disclose the period of birth and the subsequent fortunes of the most remarkable of the mountains, rivers, and lakes. This is a particularly instructive section, abounding in object lessons which show how the great forces of Nature have combined to chisel and sculpture the face of the country and to give it its present characteristic features. The third part deals with the glacial period, which has left its traces over the greater part of the country in the form of boulder clays, travelled blocks, striated rocks, &c. A neat tinted sketch map, showing the position of a great snow-field stretching from Galway to Antrim, as the axis of glacial movement, illustrates this section. Another coloured map gives at a glance the general geological features of the country. Lists of fossils are added, in which some irregularities of arrangement and nomenclature appear, the reason for which is not obvious.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

THE CAUSE OF EARTHQUAKES.

To the Editor of KNOWLEDGE.

SIR,—In KNOWLEDGE, Vol. VII., page 99, the late Editor, Mr. Proctor, wrote an article on "Some Causes of Earthquakes," in which he sought to prove that even a moderate fall in the barometric column (whereby thousands of tons of atmospheric pressure are removed from the area affected by such fall to adjacent areas) must enormously modify the pressures underneath the earth's crust. If this view is reasonable, there can be little difficulty in understanding what a real hurricane can effect in that line. Mr. Proctor evidently calculated on the assumption that it was the earth's crust alone which prevented the imprisoned matter from bursting forth. But I write to ask if you will kindly calculate the effect of a pressure of 14·7 lbs. to the square inch on the crust of the earth, supposing the density of the rock to be equal to that of granite (say 2·75, water being 1), and the depth of the crust to be say 20 miles (or such depth as the best authorities have agreed upon). As to the depth, I see that the Rev. Mr. Fisher in his "Physics of the Earth's Crust" contends for 25 miles, but I understand that other men of science do not accept his conclusions. I find it difficult to believe that a pressure of 14 or 15 lbs. on the square inch can have any effect whatever on the crust of the earth if the conditions above assumed are anything near the truth. It looks like placing a sheet of paper on the back of a turtle. Hence my troubling you with this letter. I remain,

Yours faithfully,

Leeds. "IMPERIAL."

[Assuming the average weight of the rocks of the earth's crust to be two and a half times that of water, the whole pressure of the atmosphere is equivalent to the pressure which would be caused by a stratum of such rock about twelve feet thick extending over the whole earth. Mr. Proctor's theory, set forth in the above-mentioned article, seems to be that the adding or withdrawing of many thousands of millions of tons of pressure over an area of several thousand square miles while the pressure remains unaltered on adjacent areas, might cause a tipping or movement of the earth's crust. I conclude that he only refers to inland regions not affected by the diurnal tides, which must of course cause a much greater change of local pressure than can be caused by any supposable fluctuation of the barometer. Thus, a rise of three feet in the sea level would cause an increase of pressure on the sea bottom corresponding to a rise of three inches in the barometer.

It seems certain that a slow change of pressure over a large area corresponding to an oscillation of two inches of the barometer does not either over the land or sea give rise to earthquakes—for each day as the moon passes over the meridian it decreases the pressure of the earth's crust on the material beneath it. When the moon is at its mean distance the weight, and consequently the pressure of the surface strata of the earth, immediately beneath the moon, is decreased by about a two hundred and ninety thousandth part of their total weight. If we assume the thickness of the earth's crust to be 25 miles or 132,000 feet, the change of pressure would about correspond to the weight of a stratum of rock five and a half inches thick, or to a change in the height of the barometer of about an inch of mercury, and when the moon is in the nadir the weight of the earth's crust would be increased by a somewhat similar amount. But such daily changes of pressure do not give rise to earthquakes.

There can be little doubt that sudden changes of barometric pressure affect some volcanoes, but it seems doubtful whether they ever give rise to earthquakes. Humboldt was of opinion that earthquakes only occur with changes in barometric pressure in countries where earthquakes are few; and Prof. Milne, in his interesting book on Earthquakes, published in the International Scientific Series, seems to doubt the connection between barometric changes and earthquakes. He quotes Frederick Hoffmann as having examined into the condition of the barometer at the time of 57 earthquakes which occurred at Palermo between 1788 and 1838, and found that the barometer was sinking in 20 cases when the earthquake occurred, that it was rising in 16 cases, was at a minimum in 7 cases, at a maximum in 3 cases, and the condition of the barometer was not recorded in 11 cases. Mr. Arai Ikunoske, the director of the Meteorological department at Tokio, tabulated the condition of the barometer at the time of the 396 earthquakes which occurred between May 8th, 1875, and December, 1881, and reports that the barometer was rising in 169 cases, falling in 154 cases, steady in 73 cases, below the monthly mean in 189 cases, and above the monthly mean in 192 cases. From these facts it would appear that the earthquakes of Palermo and Tokio have not any marked connection with the state of the barometer.

A. C. RANYARD.]

SQUARE AND CUBE NUMBERS.

To the Editor of KNOWLEDGE.

SIR,—You are right in surmising that Mr. Gordon's test for cube numbers is not a fresh discovery. It appeared eighty years ago, with little indication of novelty, in Barlow's "Elementary Investigation of the Theory of Numbers," chapter 5, prop. 3, as follows: "All cube numbers are of one of the forms, $9n$, or $9n \pm 1$."

Gloucester House, Your obedient servant,
Newcastle on Tyne, B. NOBLE.
1st December, 1891.

To the Editor of KNOWLEDGE.

DEAR SIR,—Referring to an interesting communication on squares and cubes in your last issue, perhaps the following chip from a mathematical workshop may be acceptable to some of your readers.

Consider the process of extracting the square or cube root of any large number, as *e.g.* the square root of 531441.

(1)

$\dot{5}3\dot{1}4\dot{4}1 = 729$
49

142	414
	284
1449	13041
	13041

(2) (abridged).

$\dot{5}3\dot{1}4\dot{4}1 = 7{\cdot}29$
49

14·29	41441
	41441

Here we observe that in (1) the last product is $9 \times 1449 = 13041$, and in (2) $29 \times 1429 = 41{,}441$.

I propose to make use of process (2) combined with a table of squares and cubes (and even higher powers), to detect, *at a glance*, the factors of *some* large numbers.

What are the factors of 281441? The ordinary process of analysis would be very tedious in the case of this number. By inspecting the table of squares, we see that

there is a square whose last four (must be *even*) figures are identical, viz. $531441 = 729^2$, and also, that the difference between the first two figures of each number, viz. 53–28= 5^2, a square. Thus $281441 = 229 \times 1229$. For $a^2-b^2 = (a-b)(a+b)$ universally, and here $729^2-500^2 = 2{\cdot}29 \times 12{\cdot}29$ (7–5=2) (7+5=12).

Again, to find the factors of 4000211—

Looking through the table of cubes, we find 5000211 =171. So we may see at once that 4000211= (171 – 100)M=71 M, for we know that $a^3 - b^3 = (a-b)(a^2+ab+b^2)$ universally, and here we have $171^3 - 100^3 = 71 \times 56341$.

It is then evident that if any proposed number to be analyzed has its last digits similar to the number found in the table of squares, cubes, &c., we may often determine the factors by inspection on the above principles.

I am, yours faithfully,

ROBT. W. D. CHRISTIE.

Wavertree Park College, Liverpool.
12th December, 1891.

PEDICULI.

To the Editor of KNOWLEDGE.

DEAR SIR,—I have read with interest the article in the December number of KNOWLEDGE upon the subject of the Pediculi, and venture to trouble you with a few remarks. The parasite of the *golden eagle*, a specimen of which I obtained from the London Zoological Gardens, has five claws at the end of each foot, and the body is greatly elongated and thin. The parasite of the *common pigeon* is also greatly elongated and thin. The *third* of the human parasites which you specify, has a single claw on each of its two front legs, but the claw is absent from the hind legs, and is replaced by an inwardly curved flattened broadish terminus, furnished with minute teeth. The sucking apparatus, as figured in your article, is well seen in this creature, as it is very transparent. It is, I presume, the same as the *P. pubis* of former days. The parasite of the *negro* is very curious, being more slender and darker than that of the white man, and its eye more developed.

I am, faithfully yours,

JOHN M. RODWELL.

THE STARS IN DR. WOLF'S CYGNUS PHOTOGRAPH.

To the Editor of KNOWLEDGE.

SIR,—In answer to your request for further observations of the faint stars in the region of the nebula near α Cygni, I carefully examined three zones on the night of November 19th. The night was very fine and clear, but the moon was very bright, being only three days after the full. The zones examined were roughly :—

	h.	m.	h.	m.
(1)	XX.	36	to XX.	44 at Decl. +44°.
(2)	XX.	28	to XX.	36 at Decl. +43°
(3)	XX.	20	to XX.	26 at Decl. +39°·30.

The powers used were the sweeping power of 70, a power of 200, and a beautiful eyepiece of Kelner construction, made expressly for me by Mr. Calver, and giving a power of 400. In spite of the bright background in every zone, all the stars shown on the photograph were seen, though some of the fainter ones were difficult, and I feel quite sure that on a dark sky it would be possible to add many more stars. As it was, other stars were occasionally glimpsed. Of course it must be borne in mind that the eye and the photographic scale are quite different; the bluish stars will appear brighter in the photo than with the eye, the red stars will appear brighter to the eye than in the photograph. I must add that the film of the $17\frac{1}{4}$ is over three years old, and my flat is badly tarnished. Hence I think that probably all the stars on the photograph, taken with 13h. exposure, are within 14·5 on Argelander's scale.

Dr. Wolf has most kindly acceded to my request to photograph the curious region south of γ Cygni, where the cluster of Wolf-Rayet and IV. Type stars occur. The photograph was taken with an exposure of 3h. 15m. Mr. Roberts had found no nebulosity connected with these stars, probably on account of the too great focal length of his telescope. Dr. Wolf's photograph seems to show traces of nebulosity all about these stars. The exposure is too short to show any definite shape, but I think there can be no doubt that the Wolf-Rayet stars, and the bright-lined star P Cygni, are directly connected with nebulous matter.

I have noticed one interesting fact, and that is, that whereas the white stars under a magnifier appear as hazy objects, the coloured stars, especially the red ones, are more sharply defined.

Tow Law, Darlington, T. E. ESPIN.
December 9th, 1891.

[The greater sharpness of the red stars is no doubt due to the chromatic dispersion of Dr. Max Wolf's instrument, which is evidently rather under corrected, so that the ultra-violet rays form a diffused patch at the focus where the red rays and the visible region of the spectrum are brought to a sharp focus.—A. C. RANYARD.]

THE GREAT NEBULOUS AREAS OF THE SKY.

By Mr. E. E. BARNARD (*of the Lick Observatory*).

I HAVE been very much interested in Dr. Max Wolf's beautiful photographs of the Milky Way in the region of α Cygni, and also in Mr. Ranyard's paper concerning them, in the October number of KNOWLEDGE.

The large nebula shown on these photographs I have been familiar with for many years in my comet-seeking. I have previously supposed it to be diffused light from dense masses of distant and faint portions of the Milky Way: the photographs, however, show it to be true nebulosity. It is easily visible in a three-inch telescope, and with a low power on the twelve-inch it is quite striking, though of course only small portions of it can be seen at once.

It resembles very much the great nebulosity in Monoceros (N.G.C 2237), which was discovered many years ago by Swift, and which I found to be a large annulus surrounding a star cluster (A.N. 2918).

There are other such masses in the Milky Way, which I hope soon to locate.

I am familiar with a number of regions in the heavens where vast diffusions of nebulous matter are situated. One of these, in a singularly blank region, lies some five or six degrees north-west of Antares, and covers many square degrees. Another lies north of the Pleiades, between the cluster and the Milky Way—a portion of this has recently been successfully photographed by Dr. Archenhold. There is a large nebulous spot in that region, easily visible to the naked eye, which I have seen for many years. When sweeping there with a low power the whole region between the Pleiades and the Milky Way is nebulous.

These great areas of nebulosity make their presence known by a singular dulling of the ordinarily black sky, as if a thin veil of dust intervened.

There is a pretty large mass of diffused nebulosity, similar

to the others mentioned in the Milky Way, in about $6^h\ 25^m$ R.A. and 9° N., which I found some years ago. There is also a great amount of the same kind of nebulosity about 15 Monocerotis (the existence of this is questioned in N.G.C — 2264—. It is very conspicuous). These great nebulous areas are specially suitable for the photographic plate, and it is only by such means that they can be at all satisfactorily located.

I have often been struck with the dull appearance of the sky to the west of the Milky Way, between it and Hercules and in Ophiuchus. This extends for many degrees to the westward of the Milky Way, and runs north and south for a great distance. I have supposed this dull dead look of the sky in that region to be due to a very distant diffused portion of the Milky Way, but the revelations of the photographic plate elsewhere in the sky would now lead one to believe it to be an immense nebulosity intimately connected with the Milky Way.

Just now I cannot more properly locate these and others that I know of, as I am referring to memory for their places.

We may yet find that at least certain portions of the Milky Way have a substratum of nebulosity.

Since writing the above, Professor Holden has called my attention to a paper by Sir William Herschel in the *Phil. Trans.* for 1811, pp. 273—278, wherein is given a table with an account of great masses of diffused nebulous matter encountered by Herschel in his surveys. Among these he mentions a "much-affected" region north-east of the Pleiades, which, I infer, is the same as that mentioned by me.

It would appear that this table of diffused nebulosities

TABLE OF EXTENSIVE DIFFUSED NEBULOSITIES.

FOR 1800·0.

No.	R. A.	P. D.	PAR.	MER.	SIZE.	ACCOUNT OF THE NEBULOSITY.
	H. M. S.					
1	0 5 2	81° 7′	1° 44′	1° 55′	3·3	Much affected with nebulosity.
2	0 12 31	86 34	3 0	2 34	7·7	Much affected.
3	0 17 17	61 24	0 41	2 40	1·8	Affected.
4	0 20 31	86 34	1 30	2 34	3·6	Much affected.
5	0 25 5	67 8	0 29	2 34	1·2	Much affected.
6	0 31 22	90 4	2 30	2 19	5·7	Appeared to be affected with very faint nebulosity.
7	0 32 54	49 23	1 33	3 1	4·7	Affected with nebulosity.
8	0 34 21	51 17	1 17	2 49	3·6	Unequally affected.
9	0 36 13	47 3	2 37	3 18	8·6	Suspected faint nebulosity.
10	0 43 32	46 58	0 26	3 18	1·4	Suspected faint nebulosity.
11	1 35 32	60 42	0 28	2 40	1·3	Suspected to be tinged with milky nebulosity
12	2 22 19	71 27	0 29	2 29	1·2	Much affected with nebulosity.
13	3 56 14	65 6	0 29	2 27	1·7	Much affected.
14	4 17 21	55 7	1 4	2 38	2·8	Suspected pretty strong nebulosity.
15	4 18 21	55 6	1 53	2 38	5·0	Suspected nebulosity.
16	4 21 35	97 44	0 30	2 15	1·1	Strong milky nebulosity.
17	4 23 14	69 23	0 29	2 36	1·3	Much affected.
18	4 38 17	69 23	0 29	2 36	1·3	Much affected.
19	4 46 17	63 25	1 46	2 31	4·4	Strong suspicion of very faint milky nebulosity.
20	5 9 44	65 6	1 23	2 27	3·4	Very much affected.
21	5 13 14	65 6	0 29	2 27	1·7	Affected.
22	5 23 59	97 1	2 31	2 31	6·3	Affected with milky nebulosity.
23	5 25 16	92 48	0 30	2 40	1·3	Affected.
24	5 27 2	94 23	1 48	2 32	4·6	Visible and unequally bright nebulosity. I am pretty sure this joins to the great nebula in Orion.
25	5 30 40	92 35	2 45	2 33	7·0	Diffused milky nebulosity.
26	5 31 58	97 1	1 56	2 31	4·9	A pretty strong suspicion of nebulosity.
27	5 38 5	88 55	1 6	2 37	2·9	Affected with milky nebulosity.
28	5 55 55	86 17	0 30	2 34	1·3	Much affected.
29	5 56 36	110 28	1 48	2 48	5·0	Affected.
30	6 33 7	48 39	0 26	3 4	1·3	Affected.
31	9 22 56	108 3	0 29	2 30	1·2	Affected.
32	9 27 19	18 21	0 24	4 4	1·6	Much affected with very faint whitish nebulosity.
33	10 6 56	98 33	3 58	2 17	9·1	Very faint whitish nebulosity.
34	10 16 1	37 58	0 24	4 9	1·7	Much affected.
35	10 34 29	26 44	0 29	3 15	1·6	Affected with very faint nebulosity.
36	10 58 24	26 44	0 42	3 15	2·3	Affected.
37	11 56 59	58 50	0 41	2 54	2·0	Affected with whitish nebulosity.
38	12 7 34	58 50	0 41	2 54	2·0	Affected with whitish nebulosity.
39	13 7 33	55 20	0 27	2 17	1·0	Much affected.
40	13 58 0	55 20	0 42	2 17	1·6	Very much affected, and many faint nebulæ suspected.
41	15 5 7	70 40	1 52	2 31	4·7	Affected with very faint nebulosity.
42	20 58 20	92 17	1 45	2 21	4·1	Much affected with whitish nebulosity.
43	20 48 50	73 38	0 29	2 52	1·4	A good deal affected.
44	20 51 4	46 51	0 59	2 53	2·8	Faint milky nebulosity scattered over this space; in some places pretty bright.
45	20 52 28	91 57	0 49	0 56	0·3	Much affected with whitish nebulosity.
46	20 53 31	47 7	1 8	3 18	3·7	Suspected nebulosity joining plainly visible diffused nebulosity.
47	21 0 26	76 3	0 44	2 46	2·0	Affected.
48	21 29 27	80 8	0 30	2 15	1·1	Much affected.
49	21 42 16	68 57	0 29	2 36	1·2	Affected.
50	22 52 36	64 47	0 29	2 47	1·3	Much affected.
51	22 53 6	64 47	0 42	2 47	1·9	Affected.
52	22 55 29	61 15	0 28	2 37	1·2	A little affected.

XUM

will just now be of extremely great value, as it at once points out, to those interested in photographing such objects, the proper pointings for their exposures.

I have taken the liberty to copy the foregoing table in full for the benefit of those not familiar with it, and who may wish to try exposures on these objects.

Herschel calls attention to the fact that the extent of these patches is uncertain. The values under the heads "Par.," "Mer.," "Size," mean the extent in the parallel, in the meridian, and the number of square degrees the nebulosity covers.

Herschel remarks that he has thus found 151·7 square degrees of diffused nebulosity, and very justly says, "But this, it must be remembered, gives us by no means the real limits of it, neither in the parallel nor in the meridian; moreover, the dimensions in the table give only its superficial extent; the depth, or third dimension of it may be far beyond the reach of our telescopes; and when these considerations are added, together with what has been said in the foregoing article, it will be evident that the abundance of nebulous matter diffused through such an expansion of the heavens must exceed all imagination."

The prophetic spirit of these remarks of Herschel is being every day made more evident through the revelations of photography.

ON HUMAN PEDICULI.—II.

By E. A. BUTLER.

(*Continued from page* 228, *Vol.* xiv.)

THE sexes of *Pediculus capitis* differ considerably in size; the female is about ⅛-inch long, but her partner is sometimes not more than half that length, and is proportionately much narrower. They may be distinguished, also, by the shape of the terminal segment of the body, which in the female, as shown in last month's figure, is notched, but in the male is evenly rounded. A large sharp-pointed organ, which may often be seen protruding from the end of the male's body, was formerly taken for a sting, and was supposed to be one of the causes of the itching produced by the insect. This, however, was a mistake, no such organ as a sting being possessed by these creatures; the instrument in question is part of the reproductive apparatus. The eggs, generally called "nits," are conical, or, rather, pear-shaped bodies which are attached to the hairs of the host, especially near their roots. The secretion with which they are moistened when laid is formed into a sort of long cylindrical collar, which clasps the hair towards the lower and smaller end of the egg, holding it up like a bracket (Fig. 3). The eggs hatch after a little more than a week, the young making their exit from the broader end. The young are quite similar in form to the adult, for the insect passes through no metamorphosis whatever, being thus in a more generalized condition than any other we have described in these papers except the "sugar-fish." Like other insects they cast their skin several times as they increase in size, and ultimately mature their reproductive organs, but no other change ensues. The young Pediculus becomes full grown in about a month, and is active throughout life and ever ready for blood-sucking. Thus man's three personal blood-sucking parasites exhibit three distinct types of development, the flea passing through a complete metamorphosis—larva, quiescent pupa, and perfect insect; the bug an incomplete metamorphosis, having an active pupa stage, and acquiring rudimentary wings; the louse no metamorphosis at all, there being no resting stage, and not the faintest semblance of wings ever appearing.

FIG. 3.—Empty Egg of *Pediculus capitis* on hair.

Pediculi are extremely prolific creatures, producing large numbers of eggs, and, as we have seen, passing rapidly into the adult and procreative condition, so that generation succeeds generation with undesirable speed and detestable powers of multiplication. Exact experiments as to the degree of fecundity they exhibit it is obviously not easy to persuade anyone to undertake; nevertheless, some naturalists have so far conquered their repugnance as to investigate the matter slightly. There has long been a popular saying, evidently begotten of despair at their excessive multiplication, that a louse can become a grandfather in twenty-four hours. This, as mentioned above, is a great exaggeration, and so thought Leeuwenhoek, who flourished about 200 years ago; he decided therefore to undertake a series of experiments in order to settle the point and to work out the life-history, if possible. The species he experimented upon would appear to have been *P. vestimenti*, the body louse, but the conclusions would probably have been similar with either species. His first thought was to hire some poor child whom he might use as a host, the method proposed being to put a clean stocking on the child's leg and to enclose two or three female lice in it, then to tie the stocking tight at the garter and keep it in this condition without change for a week, and then to examine it and see to what extent multiplication had taken place. This method of conducting the experiment, however, seemed likely to be too uncertain, and too little under his own control; not that he expected to find any difficulty in securing the services of a suitable host, but because interference with the progress of the experiment would be left so much in the child's power. On further consideration, therefore, he resolved to overcome his repugnance, and try the experiment on his own person, at the expense, as he observes, "of enduring for a short time in one leg what most poor people are obliged to suffer in their whole bodies during all their lives."

He therefore selected a fine black stocking, so that the insects might the more easily be seen, and enclosed in it two large female specimens, fastening the stocking tightly above the knee. After leaving it thus undisturbed for six days, he took it off and found one insect in the place where he had put it, and around it fifty eggs, and in another part of the stocking forty others, apparently laid by the other specimen, which, however, had escaped. Opening the body of the parent of fifty, he counted in it about fifty more, and as he adds, "who knows how many eggs it had laid before I put it in the stocking, and how many more it might then have in its body which my sight could not reach?" Having worn the stocking for another ten days, he found in it about twenty-five crawling creatures of different sizes, the largest being apparently some three days old; but the sight of such a progeny caused even his endurance to reach its limit, and he was so disgusted that he tossed the stocking and its contents into the street, and would have no more to do with it. On this slender evidence he based calculations by which he arrived at the conclusion that, though the fecundity of these insects was not nearly so great as the popular saying implied, yet that it was quite great enough to excite astonishment and alarm—that, in fact, a single female

might in the course of eight weeks become a grandmother, and witness the birth of some five thousand descendants. Even if large deductions were made from this, yet powers of multiplication would still be left which show how unsafe it would be to let even a single specimen pass unheeded.

The head louse is usually found amongst the hairs of the head, but it may occur on other parts of the body as well. According to Andrew Murray, its general appearance varies with the nationality of its host, the colour especially being considerably different when it is found on dark-skinned races; *e.g.*, on West Africans and Australians it is nearly black, on Hindoos dark and smoky, on Hottentots orange, on the Indians of South America dark brown, while on the Chinese and Japanese it is said to be yellowish. An attempt has been made, though without success, to show that these forms are distinct species. Amongst some uncivilized tribes, these insects are actually eaten, and apparently with relish. The mother, innocent of thoughts of a comb, relieves her child by hand-picking, and transfers her captures to her mouth, apparently as an easy way of disposing of them, thus imitating a habit which may also be seen in monkeys. In his "Primitive Folk," Reclus says that the Apache Indians, "when they have leisure to attend to their comfort, cover their heads, like the Australians and Andamanese, with a mud cap. This is agreeably cool, and rids them of vermin. For like reasons, they coat their bodies with a layer of mud." The Esquimaux are said to make use of a little stick ending like a spatula, to scratch themselves; with it they can more easily reach their backs and dive into the depths of their clothing.

Many remedies have been proposed against these vermin, but to secure immunity from their attacks it should always be borne in mind that the prime requisite, which is the foundation of everything else, is cleanliness. For although there is no truth in the old idea of their being spontaneously generated from dirt, yet uncleanly conditions seem to constitute a peculiarly favourable environment for the introduction and propagation of the species. Frequent head-washing, therefore, especially in the case of children, is of the utmost importance, and yet it is surprising what an antipathy many people have to letting water come in contact with their head; it would seem that this is one of the last parts of his body which, in the advance of civilization, man is prepared to submit to the action of soap and water, though, as being exposed to all sorts of begriming influences, it certainly is not the part which needs it least. The habit of using oil, pomatum, and other greasy compounds on the hair, now happily declining, though objectionable for other reasons, had its uses, and was advantageous as a preventive against these parasites, since oily matters tend to clog up their spiracles and so suffocate them. Horrible mixtures were formerly recommended as means of extermination; *e.g.*, Mouffet advises a compound made of hog's blood mixed with wine and essence of roses. The only true preventives are personal cleanliness and isolation, or avoidance of contact with those on whom the insects are found. For curative purposes, a wash made by boiling cheap tobacco in water has been recommended, as well as rubbing snuff into the roots of the hair; but for such purposes nothing better can be used than very weak solutions of petroleum or carbolic acid. Frequent washing with carbolic soap is also a good thing in this as in other afflictions connected with the skin. By those who do not object to the use of mercury compounds, an ointment made of "white precipitate" mixed with lard has been found efficacious.

Whilst *P. capitis* is usually confined to the head, *P. vestimenti*, the body louse, is found on the body at large, and as its scientific name imports, is closely connected with clothing. It is rather larger than *P. capitis*, and, as it is found on those parts of the body that are comparatively devoid of hair, it takes advantage of the seams and folds of the inner garments to deposit its eggs upon. Its chances of flourishing, therefore, depend mainly upon the clothing remaining unchanged for a long time; hence, in long marches, or on other occasions when few opportunities can be obtained for washing or changing clothes it may become troublesome. It has often been an army pest during long campaigns. When Leeuwenhoek showed some of his specimens to "a certain great personage," the latter exclaimed that they were just like those with which his soldiers were infested, and stated that the men found them much more troublesome in wet weather than in dry. In the Crimean War, it is said that the soldiers were much annoyed by these horrible creatures, finding them far more of a nuisance than *P. capitis*. Their attacks produce an intolerable itching of the skin, often accompanied with inflammation. Of course, warm baths and a thorough cleansing of the clothing are the chief remedies.

The crab louse (Fig. 4) is a very different creature from

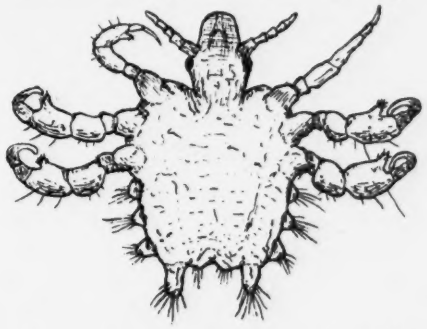


FIG. 4.—Crab Louse (*Phthirius inguinalis*).

either of those we have been considering, and is probably the most disgusting and hated of all the parasites to which mankind is subject. The thorax is much broader than in the other two species, and is even wider than the abdomen itself; this great and sudden width of the thorax, combined with the shortness of the abdomen and the lateral expansion of the legs, give it a crab-like shape which is the origin of its popular name. The two hind pair of legs are much stouter than the front pair, and their claws are very strong, and curved completely back upon the foot, giving it an intense clinging power. It ranges from $\frac{1}{20}$ to $\frac{1}{10}$ inch in length, and its life-history is similar to that of the rest, though it appears to multiply rather more rapidly and to be communicated rather more freely. As its scientific name implies it is an inhabitant chiefly of the groin, though when it exists in swarms, as is sometimes the case, it may be found on other parts of the body as well, such as the breast, the arm-pits, the beard, the eyebrows, and even the eyelashes. A frightful degree of multiplication of this insect or of *P. vestimenti* is either the cause or the accompaniment of the mysterious diseases called *pediculosis* and *phthiriasis*, which have become so celebrated through their reputed connection with some of the vilest of historical personages.

A word or two on the systematic position and classification of these vermin may fittingly close these papers: this is the more necessary as there are several other insects that might easily be confounded with them. Pediculi are now regarded as forming a degraded section of the order Hemiptera, which, as we have already seen, contains

the various species of bugs, &c. The nearest approach to the peculiar structure of the mouth in the Pediculi is certainly to be found in this order, the lice differing from the rest chiefly in having the suctorial trunk retractile, and capable of being completely withdrawn inside the head. The lice thus bear much the same relation to the rest of the Hemiptera that the fleas do to the Diptera (two-winged flies), with which they are now associated. The section of the order to which they belong is called Anoplura; but this term is often made to include another set of parasites externally something like them, but furnished with biting jaws instead of a suctorial proboscis. These are the insects called Mallophaga, or bird-lice, which devour the feathers of birds. But here again we must guard against being misunderstood. It is not implied that all parasites found on birds are true Mallophaga, nor that the latter are exclusively confined to birds. As a matter of fact, birds are troubled not only with the feather-eating Mallophaga, but with true lice allied to the Pediculi above mentioned, which suck their blood, just as the latter do that of mammals. These of course belong to the same section as the vermin whose life-history and habits we have been considering. The Mallophaga, however, being biting, not sucking insects, seem to find their nearest relatives in the order Neuroptera, to which on a former occasion we referred the little book-louse. Some of these Mallophaga also occur on mammals, whose hair they devour, just as those that infest birds make havoc upon their feathers.

THE FACE OF THE SKY FOR JANUARY.

By HERBERT SADLER, F.R.A.S.

SOLAR spots and faculæ continue to increase in number and magnitude. The following are conveniently observable minima of some Algol-type variables (*cf.* "Face of the Sky" for December). U Cephei.—January 5th, 7h. 56m. P.M.; January 10th, 7h. 36m. P.M.; January 15th, 7h. 16m. P.M.; January 20th, 6h. 56m. P.M.; January 25th, 6h. 36m. P.M.; January 30th, 6h. 16m. P.M. Algol.—January 7th, 10h. 22m. P.M.; January 10th, 7h. 11m. P.M.; January 13th, 4h. 0m. P.M.; January 27th, midnight; January 30th, 8h. 52m. P.M. A maximum of Mr. Gore's remarkable variable U Orionis (R.A. 5h. 49m. 24s. + 20° 9·3′, 1892) is due on January 11th. It varies from $6\frac{1}{2}$ to below 12 magnitude in a little less than a year, and is very red in colour. It is easily found, being 1m. 25s. f. and 6·0′ south of the $4\frac{1}{2}$ magnitude star χ Orionis.

Mercury is a morning star, but owing to his great southern declination is not well situated for observation. He rises on the 1st at 7h. 14m. A.M., or 54m. before the Sun, with a southern declination of $20\frac{1}{4}°$, and an apparent diameter of $9\frac{1}{2}''$, $\frac{6}{100}$ths of the disc being illuminated. On the 12th he rises at 6h. 22m. A.M., or 1h. 42m. before the Sun, with a southern declination of 21° 7′, and an apparent diameter of $7\frac{1}{2}''$, $\frac{44}{100}$ths of the disc being illuminated. He is at his greatest western elongation, $24\frac{1}{4}°$, on the 19th. On the 22nd he rises at 6h. 29m. A.M., or 1h. 26m. before the Sun, with a southern declination of 22° 26′, and an apparent diameter of $6\frac{1}{4}''$, $\frac{69}{100}$ths of the disc being illuminated. On the last day of the month he rises at 6h. 43m. A.M., or one hour before the Sun, with a southern declination of 22° 26′, and an apparent diameter of $5\frac{1}{2}''$, $\frac{81}{100}$ths of the disc being illuminated. During the month he describes a looped path in Sagittarius, and on the morning of the 23rd will be very close to the $5\frac{1}{2}$ magnitude star 28 Ophiuchi. Venus is an evening star, not very well situated for observation at the beginning of January, owing to her considerable southern declination, but she rapidly improves in this respect during the month. On the 1st she sets at 6h. 7m. P.M., 2h. 7m. after the Sun, with a southern declination of 20° 18′, and an apparent diameter of $11\frac{1}{4}''$, $\frac{9}{10}$ths of the disc being illuminated. On the 31st she sets at 7h. 45m. P.M., or three hours after the Sun, with a southern declination of $7\frac{3}{4}°$, and an apparent diameter of $12\frac{1}{2}''$, $\frac{84}{100}$ths of the disc being illuminated. Her brightness about the middle of January is about one-third of what it will be at its greatest, at the beginning of next June. During the month Venus passes from Capricornus into Aquarius, but without approaching any conspicuous star very closely.

Neither Mars nor Uranus rise till after midnight in January. Jupiter is an evening star, but should be looked for as soon after sunset as possible, as the planet is now rapidly nearing the west. He sets on the 1st at 9h. 43m. P.M., with a southern declination of 7° 33′, and an apparent equatorial diameter of $36\frac{3}{4}''$. On the 31st he sets at 8h. 19m. P.M., with a southern declination of 5° 13′, and an apparent equatorial diameter of $34\frac{1}{3}''$. The following phenomena of the satellites occur while Jupiter is more than 8° above, and the Sun 8° below, the horizon. On the 1st a transit ingress of the first satellite at 5h. 42m. P.M.; of its shadow at 6h. 54m. P.M.; a transit egress of the satellite at 8h. 0m. P.M. On the 2nd an eclipse reappearance of the first satellite at 6h. 29m. 11s. P.M. On the 5th an occultation disappearance of the second satellite at 7h. 20m. P.M. On the 7th a transit egress of the second satellite at 5h. 20m. P.M., and of its shadow at 7h. 37m. P.M. On the 8th a transit ingress of the first satellite at 7h. 42m. P.M. On the 10th a transit egress of the shadow of the first satellite at 5h. 36m. P.M., and a transit egress of the shadow of the third satellite at 7h. 50m. P.M. On the 14th a transit ingress of the second satellite at 5h. 14m. P.M.; of its shadow at 7h. 26m. P.M.; and a transit egress of the satellite at 8h. 7m. P.M. On the 16th an occultation disappearance of the first satellite at 7h. 3m. P.M. On the 17th a transit egress of the first satellite at 6h. 31m. P.M.; of its shadow at 7h. 32m. P.M.; and a transit egress of the third satellite at 7h. 51m. P.M. On the 23rd an occultation disappearance of the fourth satellite at 6h. 55m. P.M., and an eclipse reappearance of the second satellite at 7h. 3m. 53s. On the 24th a transit ingress of the shadow of the first satellite at 6h. 14m. P.M., and of its shadow at 7h. 11m. P.M. On the 25th an eclipse reappearance of the first satellite at 6h. 43m. 50s. P.M. On the 28th an eclipse reappearance of the third satellite at 5h. 44m. 5s. P.M. During January Jupiter describes a direct path in Aquarius, being about $8\frac{1}{4}'$ south of the 4th magnitude star ϕ Aquarii on the evening of the 12th.

Saturn is an evening star, rising on the 1st at 11h. 5m. P.M., with a northern declination of 2° 1′, and an apparent equatorial diameter of $17\frac{1}{2}''$ (the major axis of the ring system being 40·8″ in diameter, and the minor 2·6″). On the 31st he rises at 9h. 4m. P.M., with a northern declination of 2° 18′, and an apparent equatorial diameter of $18\frac{1}{2}''$ (the major axis of the ring system being 42·7″ in diameter, and the minor 2·5″). The following phenomena of the satellites may be observed (the times are given to the nearest quarter of an hour). January 2nd, $1\frac{1}{2}$h. A.M., Dione, eclipse disappearance; $11\frac{1}{2}$h. P.M. Tethys, eclipse disappearance: January 5th, 2h. A.M., Rhea, eclipse disappearance: January 8th, 2h. A.M., shadow of Titan in central transit; 5h. A.M., Titan in inferior conjunction with centre of planet, 11·5″ south: January 15th $5\frac{3}{4}$h. A.M., Titan, eclipse disappearance: January 24th, $1\frac{1}{4}$h. A.M., shadow of Titan in central transit; $5\frac{3}{4}$h. A.M., Titan in inferior conjunction with centre of Saturn, 10·8″ south.

During the month Saturn is almost stationary in Virgo, between β and η Virginis, being about 27′ south of the 6½ magnitude star 10 Virginis on the 13th.

Neptune is still visible during all the working hours of the night, rising on the 1st at 1h. 45m. P.M., with a northern declination of 19° 51′, and an apparent diameter of 2·6″. On the 31st he rises at a quarter of an hour before noon, with a northern declination of 19° 48′. During the month he describes a very short retrograde path to the north-west of ε Tauri. A map of the stars down to 10½ magnitude near his path will be found in the *English Mechanic* for October 16th, 1891.

January is a favourable month for the observation of shooting stars, the most important shower being the Quadrantids, the radiant point being in R.A. 15h. 12m. and 53° north declination, the greatest display being visible during the morning hours of January 1st to 3rd.

The Moon enters her first quarter at 1h. 12m. A.M. on the 7th; is full at 3h. 27m. A.M. on the 14th; enters her last quarter at 3h. 43m. A.M. on the 22nd; and is new at 4h. 39m. P.M. on the 29th. She is in perigee at 5·1h. P.M. on the 5th (distance from the earth, 229,770 miles); and is in apogee at 3·1h. P.M. on the 20th (distance from the earth, 251,380 miles). The greatest western libration is at 0h. 16m. A.M. on the 14th, and the greatest eastern at 8h. 13m. P.M. on the 26th.

Chess Column.

By C. D. Locock, B.A.Oxon.

All communications for this column should be addressed to the "Chess Editor, *Knowledge Office*," and posted before the 10th of each month.

Solutions of Problem No. 6 (*by C. D. L.*) Four solutions.

A. 1. R to KB8; 1...K to B3; 2. Q to K4ch, etc.
1...K to B5; 2. R to B4ch, or Q to K4ch, etc.
1...K×P; 2. R. to B4, etc.
1...P×P; 2. Q to Q3ch, or R to Q8ch, etc.

B. 1. Q to KB7; 1...K to K5; 2. Q to B4ch, etc.
1...P×P; 2. Q×Q KtPch, etc.
1...K×P; 2. Q to B4ch, etc.

C. 1. R to B4; 1...K×R; 2. Q to K4ch, etc.
1...K×P; 2. R to B4, or Q to KKt7ch, etc.
1...P×P; 2. Q to Q3 mate.

D. 1. R to KKt8; 1...K×P; 2. R to Kt5ch, etc.

Other variations as in A and C.

[Of these four solutions, the first three only were known to the composer. The problem may, perhaps, be rendered sound, though not very satisfactory, by (1) placing the White King at QR sq; (2) the Q at KR8, and the R at KB8; (3) removing the Black Pawn at KKt5, and adding a White Pawn at KR4. Key move Q to R7.]

Four Solutions received from Giu Pianissimo, J. G. Ellis, W. T. Hurley, M. B. (Jesmond), R. W. Houghton, A. Rutherford, and F. R.

Three Solutions from R. T. M., Betula, and C. S.

Two Solutions from C. T. Blanshard, J. Taylor, and T.

One Solution from Alpha, W. E. B., G. F., White Knight, and R. W. Compton.

Additional Solution of No. 5 received from W. H. W.

Black Combe.—Kieseritzky Gambits have gone out of fashion since Zukertort's exposure of the unsoundness of the attack in his celebrated game against Steinitz in the Vienna Tournament: the old-fashioned Allgaier or the Thorold-Allgaier have taken its place of late years. A Kieseritzky Gambit will be found annotated below. Now that the Solution Tourney is over, there will be more space for theory; but the openings have been pretty fully treated in the annotated games this year.

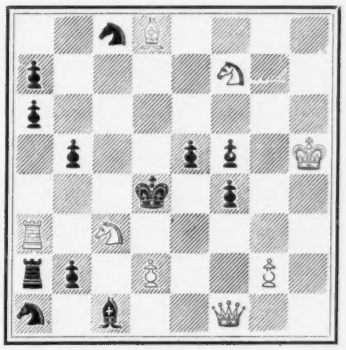
P. R. Gibbs and *E. J. Gibbs.*—After 1. . . . K to B3, 2. R to B4 will not solve the problem.

White Knight.—It is to be regretted that No. 6 was too simple for you, but you discovered only the simplest solution.

TIE PROBLEM.

[A competing problem in the *Chess-Monthly* Tournament.]

Black.



White.

White to play, and mate in four moves.

Leading Final Scores.

W. T. Hurley	50	J. Taylor	42
Giu. Pianissimo... ...	50	Betula	42
F. R.	50	J. G. Ellis	42
R. W. Houghton ...	50	Alpha	38
M. B. (Jesmond) ...	50	W. E. B.	38
A. Rutherford	50	G. F.	38
C. S.	46	White Knight	30
R. T. M.	46	K.*	22
C. T. Blanshard ...	42	T. A. Earl*	22
T.	42		

* Retired after No. 4.

Problem No. 6 has performed its invidious task, to the satisfaction, it is hoped, of at any rate the first six on the list, who now tie for the prize. In a tourney limited to six problems some device of the kind was absolutely necessary, and in the November number solvers were given rather a broad hint of what was in store for them. The problem printed above is given to decide the tie. Will those of the first six who send solutions kindly suggest what course should be taken in the event of further ties? Of the other solvers, C. S. and R. T. M. (whose solutions have been models of neatness and brevity) missed only one solution of No. 6. Betula and J. G. Ellis deserve congratulation on the high place they have taken after early unfortunate failures; while the remainder of those who scored 42 and 38 at least solved every problem. There will be no further Solution Tournament, at any rate, till next spring.

XUM

CHESS INTELLIGENCE.

An interesting match by telephone was played on December 12th between the Liverpool Chess Club and the British Chess Club. Two consultation games were played, with a time-limit of fifteen moves an hour. The first game finished was conducted by Messrs. Burn, Howard, Kaizer, and the Rev. J. Owen (Liverpool), against Messrs. Donisthorpe, Hoffer, G. Newnes, M.P., and Trenchard (London). The former, who opened with 1. Kt to KB3, speedily obtained a strong attack on the King's side, winning without very much difficulty. The other game, a Vienna Opening, between Messrs. Guest, Hirsch, Locock, and Mundell (London), and Messrs. Burn, Dod, Rutherford, and Wellington (Liverpool), resulted in a draw after more than seven hours' play. It will be noticed that Mr. Burn took part in both games. Arrangements were made for a return match, if possible, on the following Saturday.

In the Handicap Tournament of the British Chess Club the leading scores at present are—Locock, 5½ out of 6; Trenchard, 4 out of 6; and Mundell, 3½ out of 5. There are fourteen competitors. In the City of London Tournament the best scores so far are those of Messrs. Mocatta, Peachey, Ward-Higgs, Gibbons, Clayton, Moriau, and Vyse.

The Rev. W. Grundy, Head Master of Malvern College, who died early last month, was one of the strongest Chess players in the West of England. He was also one of the best fives players in England, and almost equally good at racquets.

We regret also to announce the death of Mr. J. B. Reyner, President of the Manchester Chess Club.

One of twenty "simultaneous games," played at the Newcastle Chess Club, on Tuesday, November 3rd, 1891. The score is from the *British Chess Magazine*.

[Allgaier-Kieseritzky Gambit.]

WHITE. (J. H. Blackburne.)	BLACK. (J. W. Robson.)
1. P to K4	1. P to K4
2. P to KB4	2. P × P
3. Kt to KB3	3. P to KKt4
4. P to KR4	4. P to Kt5
5. Kt to K5	5. P to KR4 (*a*)
6. B to B4	6. Kt to R3
7. P to Q4	7. P to Q3
8. Kt to Q3	8. B to Kt2 (*b*)
9. P to B3 (*c*)	9. Castles (*d*)
10. QB × P	10. Q to Ksq (*e*)
11. Kt to Q2 (*f*)	11. B to B4 (*g*)
12. Q to K2 (*h*)	12. B to Kt3 (*i*)
13. Castles KR	13. Kt to KB4 (*j*)
14. P × Kt!	14. Q × Q
15. P × B	15. Q to K2 (*k*)
16. QR to Ksq	16. Q to Qsq
17. P × Pch	17. K to R2 (*l*)
18. B to Q5 (*m*)	18. Kt to Q2
19. B to K6	19. Q × P (*n*)
20. P to KKt3	20. Q to Qsq
21. R to K2	21. B to B3 (*o*)
22. Kt to K4	22. K to Kt3 (*p*)
23. B to Q2!	23. R × P
24. Kt to B4ch	24. K to Kt2
25. Kt × Pch	25. K to Kt3
26. B × Rch	26. K × B
27. Kt(R5) × B	27. K to K3 (*q*)
28. Kt to Kt5 mate!	

NOTES.

(*a*) The old "classical" defence, now generally abandoned. B to Kt2, or either Kt to B3, may be played with perfect safety. On his next move 6 . . . R to R2 is better, the Knight being badly posted at R3.

(*b*) Obviously 8 . . . B to K2; 9. B × P, B × Pch; 10. P to Kt3 is good for White.

(*c*) Sure to be necessary sooner or later, and, therefore, perhaps better now than Kt × P.

(*d*) Dangerous looking. Kt to B3, Q to K2, or even P to KB4 at once, seem preferable.

(*e*) In order to bring out the QB. R to Ksq would not do on account of 11. B to KKt5 and 12-Castles, threatening B × Kt.

(*f*) Perhaps Q to K2 at once is better.

(*g*) Here he should play 11 . . . B to K3 first. If then 12. P to Q5, B to B4; ultimately filling the "hole" at K4 with his QKt.

(*h*) Or Castles at once, as Black dare not take the Pawn.

(*i*) B to R2 would lose a piece by 13. Q to K3!

(*j*) Falling into the ingenious trap laid for him. Probably K to R2 is as safe as anything.

(*k*) Necessary, the loss of the Queen being threatened.

(*l*) K to Rsq is better.

(*m*) This and his next move are not very intelligible. He might play Kt to K4 at once. If then 18 . . . P to Q4, 19. Kt to Kt5ch, K to Rsq; 20. Kt to K5! and wins.

(*n*) This capture, rightly rejected at move 16, increases the danger by opening the KRfile.

(*o*) In order to be able to meet R to R2 by . . . P to R5. If instead 21 . . . Kt to B3, 22. B to Kt5, P to Q4; 23. Kt to K5 wins.

(*p*) K to Kt2 is met by Kt × B, &c., but B to K2 might prolong the game. The next sacrifice seems forced.

(*q*) The speediest way of terminating a game which must be lost.

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